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# The Design of Storm Water Drains in a Modern Sewer System.

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## OUTLINE.

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- *The city water problem and storm drains.*
- *A three-fold view of the question.*
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## GENERAL FEATURES OF THE PROBLEM.

*Hydraulic Engineering and the City Water Problem.*—Broadly speaking, hydraulic engineering is the art and science of confining water. This confining is always relative rather than absolute, being an approximation toward making an unstable element stable. The city water problem consists in supplying and removing municipal water, its relative position in the hydraulic field being shown diagrammatically in Table I.

During recent years great advance has been made in the conduct of this branch of municipal affairs. Most cities now have water departments, and not a few have well-organized sewer departments. The writer believes the time not far distant when these two departments will be more widely recognized as the complements of each other, and in the more progressive communities be placed permanently in charge of trained technical men of experience and ability.

Under competent business management, such a department would be in position to benefit most largely from the advice and experience of consulting engineers, and especially would it be possible to plan definitely as to the probable future needs of a city, and then proceed with reasonable assurance of materializing such plans.

*The City Water Problem and Storm Drains.*—To most people, among whom may be included a large number of engineers, the sewerage problem means simply taking care of sanitary sewage, not appreciating the fact that some 99% of the flow in sewers would be foreign matter if viewed in this light. The realization that this view comprehends but half the problem has given rise to the economic demand for storm drains, which, though necessarily larger than sanitary sewers, can usually be correspondingly shorter, since natural drainage may be largely utilized.

*A Three-Fold View of the Question.*—Municipal hydraulic engineering deserves consideration from three points of view: the public, the taxpayer, and the engineer.

The public itself has a two-fold interest: to prevent a nuisance and to promote health. The former is by far the more potent incentive to action, although the latter is of far more vital importance; and while the danger to health from this menace has been greatly overrated, it has been even more greatly ignored. At present many of the illusions regarding disease from so-called sewer gas have been dispelled, and at the same time a thoroughly active and normal interest has been aroused regarding the need for sanitary conditions.

The taxpayer looks upon sewers and sewage disposal works as necessary evils, the construction of which is to be postponed as long as possible and then accomplished with the smallest possible outlay of cash, regardless generally of kind or quality, or of the future needs of the city. In the role of taxpayers, people are naturally obstructionists, but this point of view is largely lost sight of where the work is carried on by means of bonds or the expense is defrayed from the general treasury; therefore, when feasible, one of these methods will be found advantageous.

The city engineer too often looks upon the subject as though it were divided into three parts; house drains and fixtures to be left in the hands of plumbers and inspectors, catch basins and the like to be constructed from standard plans on file in his office, large sewers and disposal works to be constructed after consultation with a specialist. The fact is that the specialist should be consulted regarding the entire system, otherwise how can the different parts be expected to form a complete whole? The natural desire of the engineer is to eliminate the first two points of view, substituting his judgment instead. It is well to bear in mind, however, that they have to be reckoned with, for the possibility of planning and completing a satisfactory system depends almost entirely on their relative ascendency and influence.

*Essentials of a Good System.*—Until recent years, and still very largely, sewer systems were constructed haphazard and piecemeal, resulting in inefficiency and unnecessary cost. This can be obviated only by having a comprehensive plan to serve as guide in the design and construction of all sewers.

This plan should not only be comprehensive, but should be worked out in detail to a far greater degree than is generally assumed. By the very nature of things it will be many years in building, and, in fact, will never be entirely finished. This emphasizes the need for an early and rational determination of as many factors as possible, in order to best care for the present and future generations. No system would be considered modern which did not accommodate every building lot for sanitary purposes and supplement all gutters for storm runoff. This does not mean that storm drains should run to summits like sanitary sewers; on the contrary, it is usually advisable to allow storm water to flow in the gutters for an entire block or more. The first street inlet, and

consequent beginning of the sewer, should be placed as far from the summit as can be done without allowing the depth of water in the gutter to become a nuisance during heavy rains. This results in a considerable saving of money and is in accord with the accepted principle that storm drains are designed to supplement, not to replace gutters.

Another requisite is that sewers shall be constructed watertight. If it were not for glaring defects of this nature in nearly every city of the land, such a statement would be considered self-evident. The need is especially urgent in sanitary sewers. On the other hand, if there were any great advantage in doing so, storm drains might be constructed with a view to allowing slight infiltration whenever the water table was above them, since at times when it was below there would be but slight objection if water did leak out, especially during the short period of a storm. This would enable them to act as drains in the true sense of the word, keeping the permanent water plane near the level of their invert. The chief objection to this is the additional depth and cost resulting in building them below the levels of cellars. The better way is to lay small drain tile for this purpose, directly below the storm drains, wherever local conditions require the draining of the land.

The question of allowable velocities is not well understood, in spite of the fact that engineers have had to deal with it for centuries. Economy in construction requires that velocities be limited by only two things—the general slope of the surface and possible erosion of the invert. The writer is of the opinion that danger to the latter has been greatly overrated, and is conducting a series of studies at the present time with regard to maximum limits of velocity in hydraulic work. The probability is that 20 ft. per sec. over a good concrete surface is perfectly feasible. With good concrete construction there is very little danger of the invert cutting out. On the other hand, the velocity must not be so low that the cost of attendance, in the way of cleaning and flushing, is unwarrantably high. In the case of flat and low-lying territory, like New Orleans for example, this is sometimes overcome by occasional pumping stations. Present opinion favors a minimum velocity of 20 in. per sec. during the lowest stages of sanitary sewers. A rule adopted by the writer is to allow 3 ft. per sec. when the sewer is half full, which accomplishes practically the same result and is readily applied when using tables or diagrams.

Every one recognizes that capacity is a vital consideration; but while it is of prime importance that sewers be adequate for present needs and future growth, it is not so generally recognized that if they are made unnecessarily large they will be less satisfactory owing to low velocities and high cost of maintenance. This is especially true during the period of years elapsing while the territory served is being built up. It is seldom feasible, as is so often done in the case of water supply mains, to supplement sewers

by constructing parallel ones some years later. For this reason it is evident that the planning of a system to remove the water from a municipality becomes urgent much earlier than comprehensive plans for its supply.

Another essential is that the system be designed so as to minimize hand labor, cleaning the sewers as largely as possible by means of flushing with water. It is very desirable also that the flushing be by means of automatic flush tanks discharging at regular intervals, special occasions only being taken care of by using the hose. It requires a large amount of water, even when purchased at a high rate from a private company, to equal the cost of inefficient day labor in the cleaning of sewers.

As a final thought, there are two tests which may be applied in forming a judgment concerning a sewer system: that it shall promote public health and prevent a nuisance, and that the first cost shall be as low as consistent with minimum maintenance charges.

*Disposing of Sewage.*—It is usually held as a desideratum that disposal works be located to one side and at some distance from a city,—the farther the better. This last is true provided the added cost of construction and maintenance be balanced against any possible nuisance which may be caused in the proximity of the works, with consequent deterioration of property values. It by no means follows that all of the sewage should be disposed of at one point, or even by the same method and to the same extent.

A popular misconception is that the proper disposition of sewage presupposes extensive and elaborate appliances; the fact being that it varies all the way from merely an outfall sewer into a stream of water requiring no attention whatever, to a complicated system of settling basins, septic tanks, filters and sludge disposal appliances, requiring a considerable force of skilled and common labor under the direction of scientific experts. The prime requisites are that it be efficient, simple, and economical.

*The Separate or Combined System.*—After careful study has been made of the available methods of sewage disposal, it is then possible to logically consider the relative merits of the separate and the combined systems. This is seldom a problem as such, usually resolving itself into supplementing a combined system in the older parts of the city, and in the newer and unsewered portions using the one or the other, depending on local conditions, or frequently a judicious combination of the two.

In addition to meeting natural conditions, these conclusions must largely satisfy the public point of view, or rather one's judgment as to what that view is and is likely to become; and then comparing cost estimates of various tentative plans until a system is developed which may be built at as low a figure as is compatible with permanency and adequateness.

*Estimating the Amount of Sewage.*—To the lay mind, sewage is sewage wherever found; yet the composition of sewage in

America is noticeably unlike that of Europe, a marked difference appearing even in the cities of this country. This difference comes largely in the amount of dilution and in the relative proportions of sanitary sewage, trade wastes, and storm water runoff. Only the latter will be considered in this paper.

The amount of storm water for which allowance should be made is generally determined by the application of some one of the well-known formulas, such as the McMath, Hering, Burtli-Ziegler, Parmley, Gregory, and others. A very elaborate determination has lately been made by Mr. C. E. Grunsky, member of the American Society of Civil Engineers, in his studies regarding "The Sewer System of San Francisco and a Solution of the Storm Water Flow Problem". One much easier of application, although not comparable in its analytic grasp of the subject, has been proposed by Mr. Carl H. Nordell, Bureau of Sewers, Borough of Queens, New York City. A method having somewhat similar features, and comprehensive in its treatment, has been developed by the writer and is being applied in the work at Kansas City.

Whatever method is followed, it is necessary to assume some maximum precipitation for which the system will be designed. Then, from local conditions, estimate the runoff to be cared for by the different sewers.

## NECESSARY ASSUMPTIONS AND APPROXIMATIONS.

*Typical Sewer Lengths.*—By sewer length, in this connection, is meant the time required for water to flow through it, not its length in feet. Deciding upon typical lengths is a matter of judgment for each city, sometimes requiring to be changed in different portions of the same city.

Where the grades are fairly steep, as in Pittsburg, Kansas City, and other places similarly situated, time intervals for main, branch, and lateral sewers may be tentatively assumed at 40, 20, and 10 minutes respectively. In Chicago, New Orleans, and other cities having practically level streets, the periods may easily be 60, 30, and 15 minutes, or in extreme cases 2 hours, 1 hour, and ½ hour, unless there were outlets like the Chicago River, Lake Michigan, and Lake Pontchartrain, making the sewers very short. These cases are merely suggestive, and each city must be considered on its merits; in some cases two typical lengths will suffice, while in others four may be required. These time periods depend on both the absolute and relative length of the different sewers, as well as on the general shape of a city's typical rain curves.

A rigidly rational method would consider each sewer as an entity, treating it as though it were the only storm drain in the city. This would mean determining the time of surface concentration, the perviousness of the surface, the frequency with which it would be permissible to flood it, a precipitation curve suited to its individual characteristics, and by means of trial solutions its actual

time length; all of which would be manifestly impossible with the funds available for such work. There is grave question whether the present state of our knowledge would warrant such elaborate treatment, even if taxpayers were willing to pay for it.

On the other hand, a number of engineers have developed formulas with the hope of obviating many of the above difficulties. It is now pretty generally admitted that no arrangement of coefficients is possible, which shall take into account all of the varying conditions and at the same time be sufficiently simple in its application; at least, that such efforts can be only a partial success until much more data have been secured from which deductions may be made.

There would seem to be room, however, for rational effort somewhere between these two extremes of treating a city's sewers as though they were all different or else all alike, and it is this middle ground which the writer has attempted to occupy. To lessen the work which would necessarily result if each sewer were treated independently, typical sewer lengths have been adopted; and to make certain of developing really typical rain curves, the question has been met squarely by deciding on definite surcharge periods, thus setting time limits when a city can better afford to have a sewer flooded than to pay for a larger one.

*Surcharge Periods.*—It is readily conceded that most cities cannot afford to build storm drains to care for their heaviest precipitations. If this were attempted, Columbus, Ohio, would build for about 4 inches of rainfall, St. Louis and Milwaukee each for 5 inches, while Kansas City has experienced a rate of over 7 inches per hour, the average for 40 minutes being nearly 6 inches. As averages for 10, 20, and 40 minutes, the rates given in Table II, were reached during the past 10 years by the cities mentioned.

It is worth noting in the table that if one were designing for the Shreveport rains there would probably be no need for typical sewer lengths, as its intensity varied less than 5%, whether considered for a period of 10 or of 40 minutes duration. Those at Kansas City and Topeka come next with a variation of about 15%, while the one at St. Louis varies nearly 40%.

Whatever method is used in computing the required carrying capacity of the sewers, it is necessary either directly or indirectly to decide how frequently a city can afford to have its storm drains flooded rather than to build them larger, and by so doing further increase its burden of debt and expenditure. This is a matter requiring greater judgment than any other confronting the engineer engaged in storm drain design.

As a question of economics, it resolves itself into the total loss caused by flooding streets and cellars to a greater or less extent, set over against the interest on such additional expenditure as would have prevented the flooding. In this connection it is well

to remember that the loss considered must cover both the damage to property and the inconvenience which results.

As just indicated, the most careful thought should be given this phase of the subject. Each city will necessarily work out its own surcharge periods, depending on the shape of its rain curves, its financial ability, and the attitude of the people toward mortgaging the future.

In Kansas City it has been decided to design main sewers with the expectation of flooding every 10 years, branch sewers every 5 years, and laterals every 2 years. At first thought this seems too frequent in the case of laterals, but when it is borne in mind that they must be designed for 10 minute precipitations, and so must be much larger proportionally than either branch or main sewers, and that flooding in their case means simply carrying the water somewhat further in the gutters, it is readily perceived that true economy is served by making the time interval short.

*Permeability of Surface.*—It is now universally conceded that the perviousness of areas is only second in importance to the rate of precipitation, as a controlling factor in storm water runoff; since the runoff equals the precipitation less the perviousness.

The writer believes it preferable to estimate perviousness as depth in inches per hour which a given surface will absorb, rather than a given percentage of the rainfall, since there is little difference in the rate of absorption whether the rainfall be light or heavy, so long as the intensity of the downpour equals or exceeds the rate at which the surface is capable of absorbing it.

Perviousness depends on the kind and depth both of the surface soil and the sub-soil, and whether the surface is barren, covered with grass, or paved. Paved areas are usually considered impervious, but are only relatively so. This is demonstrated by the fact that the runoff from so-called impervious areas never equals the total precipitation.

In all probability the curve of perviousness is never a straight line; however, as a working basis, to be corrected later by the results of gaging, it has been assumed in Kansas City that paved surfaces absorb water at the rate of 0.50 in. per hour at the beginning of a storm, decreasing to 0.25 at the end of 15 minutes, and to 0.00 at the end of 60 minutes; that lawns and other grass surfaces absorb 0.75 in. at the beginning, decreasing to 0.50 at the end of 30 minutes, and to 0.00 at the end of 120 minutes; that garden and other barren soils absorb 1.00 in. at the beginning, decreasing to 0.75 at the end of 30 minutes, and to 0.00 at the expiration of 120 minutes. This is shown graphically in Fig. 3.

*Surface Concentration.*—The time required for surface concentration depends on the distance to catch basins and the mean slope of the surface. In calculations involving this time, the velocity of flow at Kansas City was assumed, from the meager data available, to be 100 ft. per min. for an unpaved surface having a slope

of 5 ft. to the hundred; other slopes being in proportion. Paved surfaces were assumed at twice the velocity.

The type of runoff tract used is 330 x 660 ft., being a standard city block. With this as a basis, three typical areas were worked out as follows: Type I, having 20% of paved surface and two-thirds of the remainder barren. Type II, 50% paved and equal portions of barren and lawn surface. Type III, 80% paved and one-third of the remainder barren.

These are proving satisfactory for study purposes and tentative designs. They give one, two, and three blocks as the respective distances which require 5 minutes, where the slope is 5%.

### A RATIONAL SOLUTION.

*Rainfall Data.*—There can be no doubt that more grave errors in storm drain design have been due to lack of reliable and complete

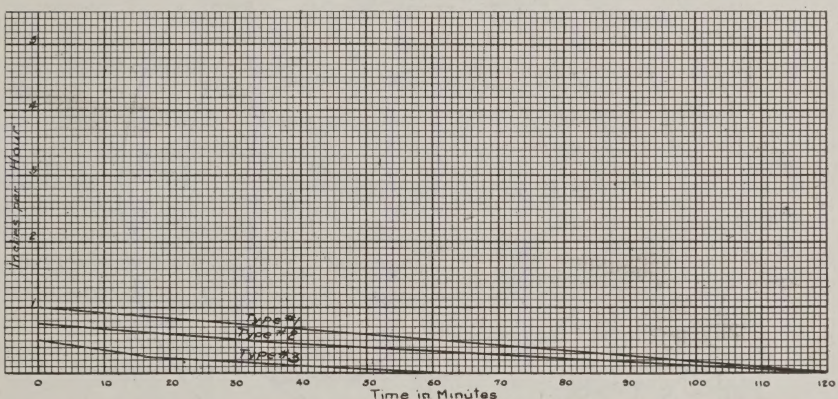


FIG. 3 - CURVES OF PERVIOUSNESS

information than to all other causes combined. This realization led the writer, during the preliminary studies in Kansas City, to devote much time and thought to gathering and compiling exhaustive rainfall data.

Since automatic records have been kept for but little more than a decade, the records from a single city are insufficient for reliable work, so data have been gathered and tabulated from the entire watershed of the Mississippi River, as shown in Fig. 1. All weather bureaus having automatic records extending over a period of 5 years or more have contributed their heavier precipitations, and the information here presented is believed to be both reliable and complete.

A careful study of the question has led the writer to conclude that for ranking rains in the order of their intensities, the method of average precipitation is at once simple and adequate, therefore satisfactory. This method has been used in preparing the following

tables. They were computed for the 40, 20, and 10 minute periods by the use of the planimeter, as illustrated in Fig. 2, the areas being taken between the vertical lines, which are equal maximum ordinates enclosing the given time intervals.

The first step, then, after the records are gathered and plotted, is to determine the average intensity of each rain for the different time intervals. It should not be lost sight of that these averages in no wise enter into the computations of sewer discharge, but are

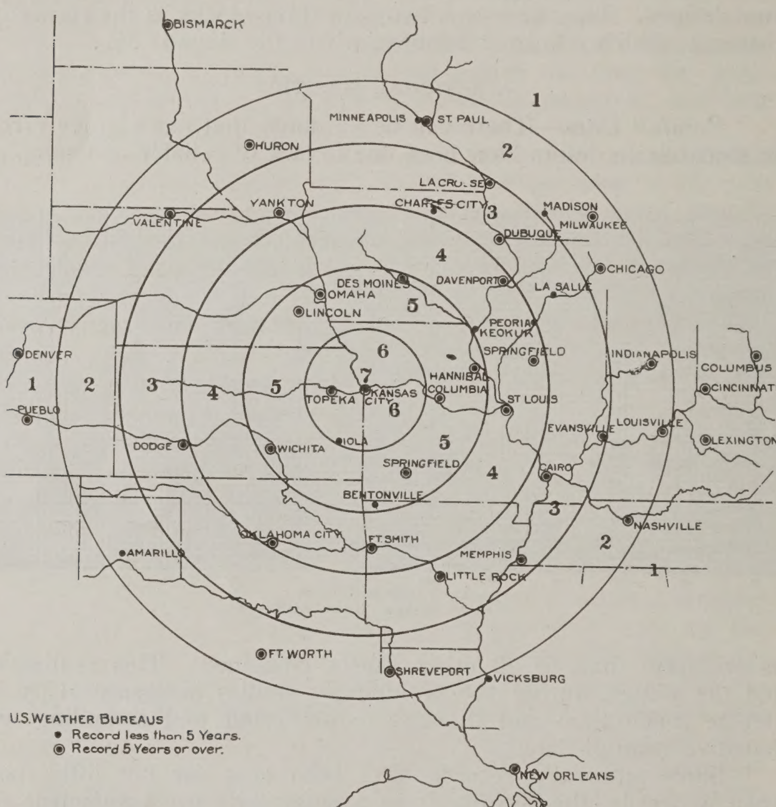


Fig. 1. Map Showing U. S. Gauging Stations.

used merely in the arrangement of the tables. Tables III, IV, and V contain the data so arranged.

*Typical Precipitation Curves.*—The matter of greatest importance in planning and designing a storm sewer system is the determination of typical precipitation curves. The exercise of judgment comes mainly in the selection of surcharge periods, the following work being largely a question of mathematics.

It is essential that the rainfall data be from automatic gages which record the depth in inches falling each five minutes. This makes it possible to plot curves showing both the total and rate of precipitation, the usual way being to use time as abscissas and rates per hour as ordinates.

It is unnecessary to plot the records of all rains, as much time and labor can be saved by setting a minimum limit below which rains will be omitted. The choice of this in no way affects the validity of the method or the correctness of the results secured. For the Mississippi Valley, and the Middle West generally, very satisfactory limits are as follows: a precipitation of 0.25 in. during some five minutes of the storm and a total precipitation of at least an inch of rainfall.

In order to present clearly the method of computing a typical rain curve, a simple illustration will be used. Suppose a city has ten rains in ten years; it is clear that the hardest one occurred once in the ten years; that one equal to or exceeding the next hardest occurred every five years, for it and the hardest both occurred during the ten years, or an average of every five years for the one or the other. The same line of reasoning shows that one equal to or exceeding the fifth hardest occurred every two years.

The method is still logical no matter how many rains occurred, and if the ten hardest are used, being as many as the number of years considered, it determines what rains may be expected to flood the sewers for any surcharge periods selected. Since data are used from different gaging stations, it becomes necessary to reduce their records to a common basis. Probably 10 is the most convenient one to use, so this will be employed throughout the discussion. If the record has been kept for more than 10 years, say 11 for example, each rain must be weighted by 10/11, using the actual intensity, but taking 11 instead of 10 rains into account. Likewise, if the record is available for only 6 years, each rain must be weighted by 10/6. It is hardly necessary to mention that the longer the record the more satisfactory its use, since interpolating is always preferable to exterpolating. If some number other than 10 years had been selected as standard, the numerator of the above fractions would correspond.

Another point needs to be considered at this time; all engineers will agree that cities situated in the same drainage basin may be expected to show rain curves somewhat similar in form and intensity, so that the records of all such cities may properly be considered in estimating future probabilities; they will likewise agree that a city's own rains will be a truer index of what may be expected in the future than the precipitations at other places several hundred miles distant. For this reason, the records have been weighted, giving Kansas City a weight of 7,

cities within 100 miles 6, 200 miles 5, and so on, until those at a distance greater than 500 miles, but still within the Mississippi Valley, are given a weight of 1.

Table VI, gives the final weights of the different cities, and the method of their computation. These have been obtained as follows: the number of years for which rains are considered is divided by the length of time the record is available, and this quotient is multiplied by the distance weight of the city. For Topeka, Kansas, this gives

$$10 \div 8\frac{1}{2} \times 6 = 7.$$

With surcharge periods of 10, 5, and 2 years already determined upon, the *Total final weight* is multiplied by 1, 2, and 5

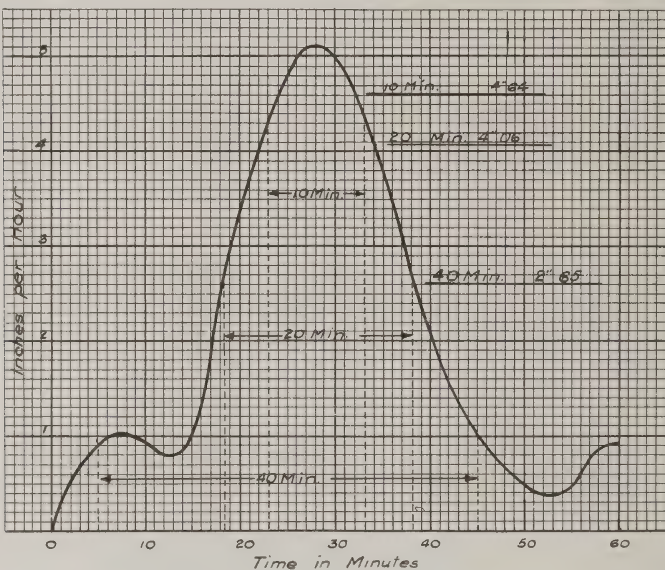


FIG. 2 — PRECIPITATION CURVE. COLUMBIA, MO.

(obtained by dividing 10 by 10, 5, and 2) as given at the bottom of Table VI. This gives partial totals of 149 to be used with Table III, 298 with Table IV, and 745 with Table V. Opposite these in the tables we find 2.62, 3.26, and 3.42, which are the average intensities of the three typical precipitation curves.

It now remains to determine the form of each of these curves. The 40 minute curve will be used to illustrate the operation. This is best seen by reference to Table IX, where it will be noticed that ten weights above and ten below have been used. Either more or less rains might have been used, depending on the judgment of the engineer as to how many are required to derive a curve which shall be truly typical in shape. Since the

intensity for the period is in no wise affected, a comparatively large error in judgment results in but slight error in design, thus reducing the personal equation to a minimum.

Table VII, gives the rains thus selected. The amount of precipitation for each 5 minutes is given, with the beginnings of the rains directly under each other. In Table VIII, these are arranged symmetrically with regard to their maximum intensities, since this arrangement is best adapted to obtaining a curve which shall most nearly represent them in its form characteristics.

In Table IX, the same arrangement is preserved, but the different values are multiplied by the respective weights of the rains taken from Table III. The columns are then added and the sums divided by 20, since a total of twenty weights was used. In order to obtain ordinate values for plotting, these quotients are multiplied by 12 so as to get rates per hour. These rates

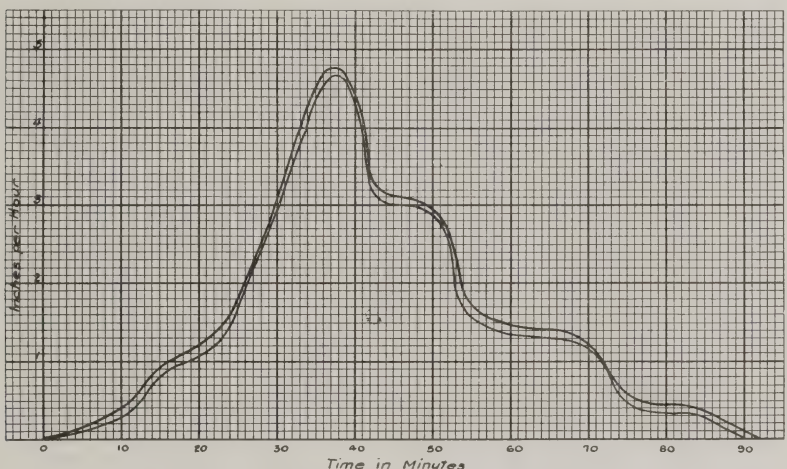


FIG. 5 - RESULTANT CURVE FOR 40 MIN. PERIOD

are given in the last line, the curve being shown by the lighter line of Fig. 5. This gives the correct form of the typical precipitation curve desired, but not necessarily its magnitude, which may be either more or less. In the present instance the curve has to be increased slightly in intensity, this being done so as to make the rate for 40 minutes 2.62 in. per hour, as given in the table. The final curve is shown by the heavier line in the figure.

As previously suggested, the method contemplates the use of a precipitation curve for each typical sewer length, varying in number probably from one to four in different cities. To make the need for this apparent, suppose the rain curve for 40 minute sewers were used for 20 and 10 minute sewers, it would in effect greatly reduce their surcharge periods.

Taking the rain immediately above 2.62, which is the average intensity for 40 minute sewers, the *Partial Totals* in the different tables are found to be 149, 796, and 1241. Dividing each of these by 149 gives 1, 5.35, and 8.33; then dividing 10 by each of these gives 10, 1.86, and 1.20. In other words, the 40 minute sewer would be flooded every ten years (which had been assumed), the 20 minute sewer a little oftener than every two years and the 10 minute sewer a little more frequently than once every fifteen months.

Or take the illustration the other way; suppose the rain curve for 10 minute sewers were used for 40 and 20 minute drains, it would have the effect of increasing their surcharge periods. The average intensity would then be 3.42, opposite 35, 229, and 745 in the columns of partial totals. Dividing as before gives final quotients of 42.6, 6.5, and 2; which means that the different classes of sewers would be flooded about every 40, 6, and 2 years respectively.

The tables can readily be used to determine the surcharge periods for any desired intensity of rain. If a precipitation can be found which will give satisfactory surcharge periods for the different classes of sewers, it would in effect reduce them to one. This is the ideal condition, but should not be expected to occur often in practice.

*Designing the Sewers.*—With the time length of a sewer approximated and the typical rain determined, it is then only necessary to decide from this rain curve the amount of runoff which will reach the sewer from each runoff tract, and use this in conjunction with the grade that can be secured. With these data in hand, the size of sewer and velocity of flow are readily computed.

Referring to Fig. 4, it illustrates how the runoff from the different tracts is combined so as to obtain a cumulative effect comparable with actual conditions. It will be noticed that the calculations are all graphical, this method being simple, rapid, and of sufficient accuracy. The different values might be added, but the work would be laborious and there would be greater danger of errors creeping in. By repeating this process wherever more water enters the sewer, the required size is synthetically built up.

With the velocity of flow determined, the time is computed which will be required for the water to flow from the first catch basin to the second, or to where another sewer joins it, the writer's practice being to compute time lengths for periods of five minutes or over, using the nearest five minutes in adjusting the curves. Whenever our knowledge of surface concentration shall have become sufficiently definite, it will be advisable to work to minute intervals instead of only to five minutes.

A curve is then drawn which in magnitude equals the typical

curve multiplied by the area drained, for each of the runoff tracts, the second one being moved toward the right as many minutes as the time required for the water to flow from the first point to the second. This is shown in the figure by *Tract 1* and *Tract 2*. The two curves are then combined by making a new one with ordinates equal to the sum of their ordinates above the lines of *Perviousness*. This new curve represents the flow below the junction point.

When the outlet is reached, the shape and magnitude of the last curve gives a correct graphical representation of the resulting flow to be expected at this point. At first glance it would seem

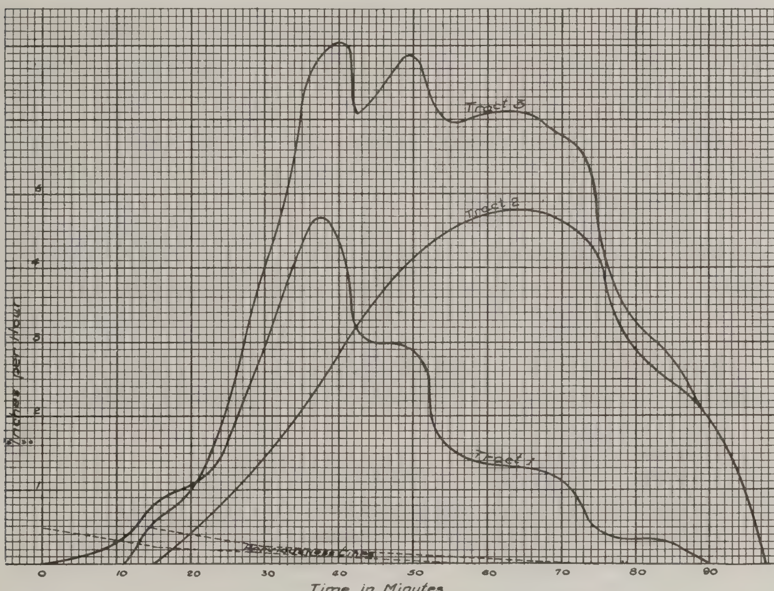


FIG. 4 - CUMULATIVE METHOD OF COMBINING DISCHARGES.

that much time would be consumed. On the contrary, it is surprising how rapidly and certainly results can be obtained.

To design a sewer for any part of the city, always begin with the laterals and work toward the branches and from that to the main sewers. In other words, follow with the computations the order followed by the water in filling sewers. Whenever advisable the method may be combined with the use of any of the formulas already mentioned.

*Numbering Sewers.*—If some simple and yet rational system of numbering sewer districts be adopted, it not only saves a great deal of inconvenience but much lost time and frequent errors. This may be illustrated by the method proposed for

Kansas City. By charter the entire territory within the corporate limits is divided into sewer divisions and these into sewer districts. For purposes of designing, the divisions are subdivided into drainage areas, these into runoff tracts, and these again into sewer districts. See Fig. 6.

Including the new territory, eight divisions are being proposed for the city. These are being divided into drainage areas, not to exceed nine for each division; these again into runoff tracts, not to exceed nine for each area; the tracts being divided in the same way into sewer districts, the highest possible number being 8999. As a matter of convenience, the numbers follow up the sewers. This can best be illustrated by an example.

Sewer district number 5439 means that it is located in division 5, drainage area 4 of this division, runoff tract 3 of this area, and sewer district number 9 in this tract. It also shows that the property embraced within its limits is located near the center of the city, otherwise it would not be in division 5; that it is near the middle of that division, being area No. 4; that it is in the lower part of the area and the highest part of the tract, as indicated by the figures 3 and 9.

It is not only of great advantage in at once locating a sewer, since the sewer has the same number as the district which it serves, but is of equal importance while designing, since each sewer flows into one of a lower number, thus avoiding occasion for mistakes and so insuring accuracy and rapidity in the work.

*Essentials of the Method Outlined.*—The emphasis in the method proposed above is placed on the following points:

Surcharge periods.

Typical sewer lengths.

A typical rain curve for each sewer type.

Method of deducing these curves.

Method of estimating perviousness.

Cumulative method of sewer computation.

Most of the earlier attempts to solve the storm flow problem considered these same features, although frequently not with such explicitness, as the requirements were not then so well understood. Aside from the method of estimating the perviousness, only brief consideration is given to the subjects of permeability and time of surface concentration, since these phases of the question still wait on the gathering of more data, so that something approaching complete and reliable information may be at hand.

*Points Which Commend the Above Method.*—It follows nature in being cumulative in results obtained.

It is a combined analytic and synthetic method.

The direction of storms can readily be allowed for.

It is adapted to any degree of refinement.

There is no uncertainty as to where maximum periods occur.

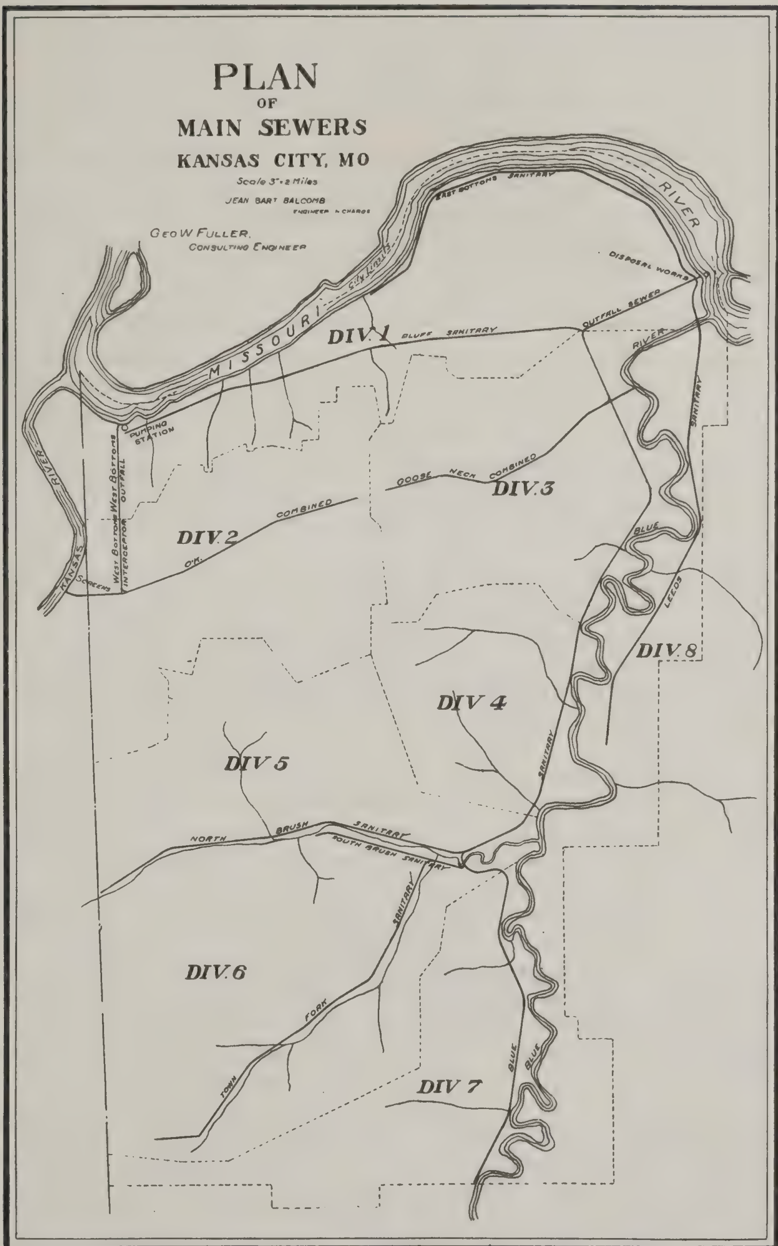


Fig. 6. Plan of Main Sewers—Kansas City, Mo.

It can be used to solve the problem independently, or in conjunction with any other method.

Wherever it is necessary to exercise judgment, the conditions to be met are definite and certain.

No averages are used in computing capacities, the actual rain variations being followed.

There are no coefficients to be approximated, with consequent probability of large and uncertain errors.

It does not depend on formulas or difficult mathematical determinations, yet secures results agreeing with the facts up to the limits of the data available.

### ACTUAL CONSTRUCTION AND RESULTS TO BE EXPECTED.

*Materials of Construction.*—The decision as to what materials to use in construction has been controlled largely in the past, and still is to some extent, by the materials manufactured or for sale by local firms, through political affiliations, and social friendships. This is being greatly lessened owing to a closer study of the subject my municipal hydraulic engineers, and a larger interest and better understanding by the general public of the needs and requirements of a thoroughly up-to-date sewerage system.

It may be a matter of surprise to some that rectangular wooden sewers have been built in a number of instances and have given excellent service through a term of years, but finally becoming at least indirectly a public nuisance. It is not be be supposed that any engineer would recommend such construction today, as the defects of wood for this purpose are now well recognized.

For large sewers, brick was well-nigh universally used until concrete was found to be a much better material. The use of brick is growing less and less, owing to the large number of joints and the lack of tensile strength in the completed structure. This is emphatically true unless the sewers are lined with cement mortar. A special invert is also required as many serious cases of erosion are on record. The chief reasons for using brick were its cheapness, its availability, the supply of suitable skilled labor, and the ease with which vitrified brick or Belgian blocks could be laid in the invert, after this was found necessary in order to avoid their cutting out where even moderate velocities were used.

For small sewers, it is generally agreed that vitrified pipe, with bell and spigot joint well caulked and then filled with portland cement mortar, is the best material at hand. At the same time it is fully recognized that such frequent joints make it an undesirable material, partly because it is almost impossible to inspect each individual joint in its entirety, and partly because it is, to say the least, very inconvenient to do good work and make the joints water tight. When laid on steep slopes, the

joints, being of a material foreign to the pipe and adhering only fairly well, make natural places for erosion to begin. This frequently continues until water finds its way in or out of the sewer, depending on the level of the water table at different seasons of the year.

The present concensus of engineering opinion favors the use of concrete, generally reinforced, and either monolithic or in the form of pipe, for nearly all sewers larger than 30 inches inside diameter. Sewers 24 inches to 30 inches are still debatable ground. Concrete pipe with longitudinal bar reinforcement possesses many of the characteristics which must obtain in the sewer construction material of the future. It is to be hoped that a substitute for vitrified pipe may be found, or that a better joint may be devised, or else that it may be found feasible to construct small sizes of concrete pipe with an entirely satisfactory method of joining them.

*Contracts and Specifications.*—Much good work has been done along this line in the past few years, and yet the present forms of contract and specifications are far from satisfactory. In a letter to *Engineering-Contracting,* published February 10, 1909, the writer made the following statement, which has not thus far been questioned, and which he wishes to reiterate in the present instance:

> "In order to draw up an equitable contract, or judge of one that is drawn, the first requisite is that it shall be fair to both parties, assuming them both to be honest and actuated by right motives. The second is to have it formulated so there is no motive for dishonesty by either party—so that whether an honest or dishonest course is followed it will result in a gain or loss to both parties, never a gain to one and a loss to the other."

Of the various modifications and forms proposed, the one which seems to be entirely adequate, and at the same time adapted to existing needs and conditions, may best be described as follows: Cost plus a fixed sum, with bonus and forfeit clause regarding both the time limit and the total expenditures; all extras to be paid for by cost plus a percentage.

*Inspection.*—With the old form of contract, it had become tacitly understood that laxity of inspection would counterbalance rigor of contract. The result has been that it often did far more than this. Whereas the specifications called for practically a perfect sewer, the actual construction fell unwarrantably below even reasonable requirements.

On the other hand, with the more reasonable forms of contract now coming into vogue, it is beginning to be possible to make the work of the inspector something more than a matter of form, and to really get sewers built very closely in accordance with the designs. The writer is firmly of the belief that a reason-

able contract with honest inspection will correct many of the evils from which urban communities now suffer.

*Maintenance.*—The maintenance and repair of sewers, having been entirely removed from the engineering department in all of the larger cities, will be passed with a single thought.

While the day labor employed by cities is in many cases better than it formerly was, yet it is frequently untrustworthy and cannot be depended upon to carry out regulations regarding cleaning and flushing sewers. Also, it is notoriously inefficient. For the sake of economy, it is advisable to place automatic flush tanks at practically all dead ends, and to construct street inlets rather than catch basins, except where the latter are absolutely necessary, depending mainly on flushing to keep the sewers clean. It is also advisable, in sanitary sewers, to see that the building regulations require a vent from the soil pipe to the roof of each building, so that when sanitary sewage conveyed by the separate system has once passed the trap inside of the building, there shall be no other traps until it is finally discharged through the outfall sewer or at the disposal works.

*Degree of Accuracy.*—Engineers are prone to approach this problem as though it could be solved exactly. This is the desideratum, but it cannot be even closely approximated until much more experimental work has been done and a large amount of additional data has been gathered, so that judgments may be formed, rules formulated, and the practice standardized.

Engineers go to great lengths to determine the exact daily consumption per capita and the amounts of water used by manufacturing concerns, so as to know very closely the amount of house sewage and trade wastes; then very largely guess at the amount of seepage water, after which the figures are increased perhaps 50% to allow for periods of maximum flow; and then the sewer is designed, so that on the basis of these computations it will run two-thirds or three-fourths full during maximum flow.

In order to arrive at the amount of runoff, engineers make careful estimates of the perviousness of the surface, its general slope and the time of surface concentration; and then arbitrarily assume some depth of rain which may or may not closely approximate the maximum rainfall for that city, or some predetermined amount less than this maximum.

This is all necessary, and the writer warmly endorses doing all such work as accurately as possible, laying stress on the refinement of details as rapidly as our knowledge warrants such action, but it should not be expected that absolutely correct results have been attained, after all this is done. Neither is it to be inferred that in this respect the hydraulic engineer is behind the structural, mechanical, or other engineers of the profession.

A sewer system should be designed for 25 years, for 50 years, for all time; and engineers accomplish this with a remarkably small margin of error. Yet no one would think of expecting an architect or structural engineer to build a factory so that it would handle a small output economically and at the same time be capable of caring for the unknown future growth of the business. If in the erection of a steel frame building or in the construction of a machine, where working conditions are pre-determined and the strength and properties of the steel may be found out completely in the laboratory and testing machine, it is deemed necessary to allow factors of safety from 3 to 20; hydraulic engineers are to be congratulated, since many of the conditions with which they deal are difficult and some of them practically impossible to determine, yet withal satisfactory results are achieved.

Table I. FIELD COVERED BY HYDRAULIC ENGINEERING.

| | | |
|---|---|---|
| Hydraulic Engineering | Agricultural | Drainage. Irrigation. |
| | Municipal | Waterworks. Sewerage. |
| | Power | Water Electrical. |
| | Transportation | Harbor improvements. Ship canals. River improvement. |

Table II. HEAVY PRECIPITATIONS, GIVING RATES PER HOUR.

| City. | Date. | Time Periods. 10 min. | 20 min. | 40 min. |
|---|---|---|---|---|
| Kansas City, Mo. | 8-23-06 | 6.78 in. | 6.48 in. | 5.79 in. |
| St. Louis, Mo. | 7 -8-98 | 6.03 in. | 4.92 in. | 3.66 in. |
| Milwaukee, Wis. | 6-24-04 | 5.78 in. | 4.64 in. | 3.98 in. |
| Ft. Worth, Tex. | 9-21-00 | 4.90 in. | 4.14 in. | 3.70 in. |
| Cairo, Ill. | 6-28-05 | 4.74 in. | 3.84 in. | 3.32 in. |
| Columbus, Ohio | 7-11-97 | 4.57 in. | 4.11 in. | 3.51 in. |
| Little Rock, Ark. | 7-11-03 | 4.42 in. | 3.98 in. | 3.36 in. |
| Topeka, Kans. | 8- 2-03 | 4.02 in. | 3.72 in. | 3.48 in. |
| Shreveport, La. | 7-23-05 | 3.86 in. | 3.74 in. | 3.70 in. |

Table III.

HEAVY PRECIPITATIONS.

40 MINUTES.

| City. | Date. | Av. Rate per hr. | Final Wt. | Partial Tls. |
|---|---|---|---|---|
| Kansas City, Mo. | 8-23-06 | 5.79 | 7 | 7 |
| Milwaukee, Wis. | 6-24-04 | 3.98 | 2 | 9 |
| Shreveport, La. | 7-23-05 | 3.70 | 4 | 13 |
| Ft. Worth, Tex. | 9-21-00 | 3.70 | 3 | 16 |
| St. Louis, Mo. | 7- 8-98 | 3.66 | 4 | 20 |
| Columbus, O. | 7-11-97 | 3.51 | 1 | 21 |
| Topeka, Kans. | 8-02-03 | 3.48 | 7 | 28 |
| Topeka, Kans. | 9-13-01 | 3.40 | 7 | 35 |
| St. Paul, Minn. | 8- 9-02 | 3.36 | 2 | 37 |
| Little Rock, Ark. | 7-11-03 | 3.36 | 3 | 40 |
| Cairo, Ill. | 6-28-05 | 3.32 | 3 | 43 |
| Ft. Worth, Tex. | 3-25-04 | 3.20 | 3 | 46 |
| Columbia, Mo. | 5-31-02 | 3.20 | 5 | 51 |
| Little Rock, Ark. | 5- 8-00 | 3.14 | 3 | 54 |
| Cairo, Ill. | 6-13-99 | 3.10 | 3 | 57 |
| Ft. Worth, Tex. | 6- 3-04 | 3.10 | 3 | 60 |
| New Orleans, La. | 8-25-04 | 3.09 | 1 | 61 |
| Davenport, Ia. | 8-26-07 | 3.06 | 7 | 68 |
| Omaha, Neb. | 7- 6-98 | 3.03 | 5 | 73 |
| Columbus, O. | 6-23-01 | 3.02 | 1 | 74 |
| Wichita, Kans. | 7- 6-04 | 2.96 | 10 | 84 |
| Dodge City, Kans. | 6- 7-99 | 2.94 | 3 | 87 |
| Wichita, Kans. | 9-17-05 | 2.92 | 10 | 97 |
| Louisville, Ky. | 8- 8-98 | 2.90 | 2 | 99 |
| New Orleans, La. | 3-17-04 | 2.86 | 1 | 100 |
| Nashville, Tenn. | 8-21-02 | 2.82 | 2 | 102 |
| New Orleans, La. | 7-19-01 | 2.81 | 1 | 103 |
| New Orleans, La. | 7-19-01 | 2.81 | 1 | 104 |
| Columbia, Mo. | 8-25-00 | 2.78 | 5 | 109 |
| Oklahoma City, Okla. | 6- 4-04 | 2.78 | 4 | 113 |
| Little Rock, Ark. | 11-28-05 | 2.78 | 3 | 116 |
| Kansas City, Mo. | 9-14-05 | 2.77 | 7 | 123 |
| Evansville, Ind. | 8-14-06 | 2.74 | 4 | 127 |
| Nashville, Tenn. | 6-15-97 | 2.72 | 2 | 129 |
| New Orleans, La. | 7-11-04 | 2.71 | 1 | 130 |
| Oklahoma City Okla. | 5-29-05 | 2.70 | 4 | 134 |
| Des Moines, Ia. | 7-14-07 | 2.67 | 5 | 139 |
| Evansville, Ind. | 9- 2-00 | 2.66 | 4 | 143 |
| Lexington, Ky. | 8-22-00 | 2.65 | 1 | 144 |
| Columbia, Mo. | 8-22-05 | 2.65 | 5 | 149 |

(149 weighted rains occur every 10 years.)

| City. | Date. | Av. Rate per hr. | Final Wt. | Partial Tls. |
|---|---|---|---|---|
| Shreveport, La. | 6- 1-06 | 2.62 | 4 | 153 |
| New Orleans, La. | 3-14-03 | 2.60 | 1 | 154 |
| Springfield, Mo. | 7-26-05 | 2.58 | 10 | 164 |
| Topeka, Kans. | 6-24-03 | 2.58 | 7 | 171 |
| Little Rock, Ark. | 5-21-98 | 2.56 | 3 | 174 |
| Hannibal, Mo. | 5-26-06 | 2.54 | 5 | 179 |
| Wichita, Kans. | 6-15-05 | 2.53 | 10 | 189 |
| Nashville, Tenn. | 9- 1-00 | 2.53 | 2 | 191 |
| New Orleans, La. | 3-14-03 | 2.51 | 1 | 192 |
| Little Rock, Ark. | 9-15-98 | 2.50 | 3 | 195 |
| Milwaukee, Wis. | 9- 2-00 | 2.50 | 2 | 197 |
| Cincinnati, O. | 7- 5-97 | 2.50 | 1 | 198 |
| Dubuque, Ia. | 8-15-07 | 2.50 | 5 | 203 |
| Shreveport, La. | 6-27-02 | 2.47 | 4 | 207 |
| Lincoln, Neb. | 5-10-05 | 2.45 | 6 | 213 |
| New Orleans, La. | 3-14-03 | 2.44 | 1 | 214 |
| Springfield, Mo. | 7-19-06 | 2.44 | 10 | 224 |
| Davenport, Ia. | 9- 9-03 | 2.44 | 7 | 231 |
| Nashville, Tenn. | 6-15-05 | 2.43 | 2 | 233 |
| Ft. Worth, Tex. | 5- 2-06 | 2.40 | 3 | 236 |
| Memphis, Tenn. | 8- 9-05 | 2.38 | 3 | 239 |
| Nashville, Tenn. | 9- 4-06 | 2.38 | 2 | 241 |
| Nashville, Tenn. | 6- 9-03 | 2.38 | 2 | 243 |
| New Orleans, La. | 4-25-07 | 2.37 | 1 | 244 |
| Columbia, Mo. | 5-25-03 | 2.37 | 5 | 249 |
| Milwaukee, Wis. | 9-17-07 | 2.36 | 2 | 251 |
| Lincoln, Neb. | 8-15-00 | 2.32 | 6 | 257 |
| Dodge City, Kans. | 8-18-04 | 2.32 | 3 | 260 |
| Kansas City, Mo. | 9- 9-03 | 2.32 | 7 | 267 |
| Oklahoma City, Okla. | 5- 5-99 | 2.32 | 4 | 271 |
| Dodge City, Kans. | 7-19-97 | 2.32 | 3 | 274 |

| City. | Date. | Av. Rate per hr. | Final Wt. | Partial Tls. |
|---|---|---|---|---|
| New Orleans, La.. | 8- 5-98 | 2.30 | 1 | 275 |
| Kansas City, Mo... | 3-24-04 | 2.30 | 7 | 282 |
| Huron, S. D..... | 8- 8-04 | 2.30 | 2 | 284 |
| New Orleans, La.. | 7-11-06 | 2.29 | 1 | 285 |
| Kansas City, Mo.. | 7-14-07 | 2.26 | 7 | 292 |
| Dodge City, Kans.. | 7-21-07 | 2.26 | 3 | 295 |
| Huron, S. D...... | 6-27-05 | 2.26 | 2 | 297 |
| La Crosse, Wis.... | 7- 9-03 | 2.26 | 5 | 302 |
| Columbia, Mo..... | 6-25-99 | 2.24 | 5 | 307 |
| Shreveport, La.... | 4-11-05 | 2.24 | 4 | 311 |
| Yankton, S. D.... | 8-23-06 | 2.22 | 3 | 314 |
| St. Louis, Mo..... | 8- 6-07 | 2.20 | 4 | 318 |
| Little Rock, Ark... | 6- 1-98 | 2.20 | 3 | 321 |
| Hannibal, Mo..... | 8- 8-99 | 2.20 | 5 | 326 |
| Milwaukee, Wis... | 8-23-98 | 2.20 | 2 | 328 |
| Cincinnati, O..... | 7-22-06 | 2.19 | 1 | 329 |
| Dodge City, Kans.. | 6-17-06 | 2.18 | 3 | 332 |
| St. Paul, Minn.... | 7-30-04 | 2.16 | 2 | 334 |
| Wichita, Kans.... | 7-14-04 | 2.16 | 10 | 344 |
| Evansville, Ind.... | 9- 2-04 | 2.16 | 4 | 348 |
| Columbia, Mo..... | 9-17-05 | 2.15 | 5 | 353 |
| Shreveport, La.... | 5- 7-07 | 2.14 | 4 | 357 |
| Columbia, Mo..... | 6-14-98 | 2.12 | 5 | 362 |
| Indianapolis, Ind.. | 3-31-04 | 2.12 | 2 | 364 |
| Cairo, Ill........ | 6-22-97 | 2.11 | 3 | 367 |
| New Orleans, La.. | 5-23-07 | 2.10 | 1 | 368 |
| St. Paul, Minn.... | 8-18-07 | 2.10 | 2 | 370 |
| New Orleans, La.. | 4-17-01 | 2.08 | 1 | 371 |
| Ft. Smith, Ark... | 6-30-07 | 2.08 | 7 | 378 |
| Des Moines, Ia.... | 7-18-04 | 2.08 | 5 | 383 |
| New Orleans, La.. | 9-16-01 | 2.06 | 1 | 384 |
| Oklahoma City Okla. .......... | 5-23-03 | 2.06 | 4 | 388 |
| Yankton, S. D..... | 9-20-02 | 2.06 | 3 | 391 |
| Valentine, Neb.... | 7-21-04 | 2.06 | 3 | 394 |
| Kansas City, Mo.. | 8- 2-05 | 2.06 | 7 | 401 |
| Evansville, Ind.... | 7-20-04 | 2.06 | 4 | 405 |
| Dodge City, Kans.. | 7-23-99 | 2.06 | 3 | 408 |
| Shreveport, La.... | 5- 3-06 | 2.05 | 4 | 412 |
| Valentine, Neb.... | 7- 9-07 | 2.04 | 3 | 415 |
| Memphis, Tenn.... | 7-16-06 | 2.04 | 3 | 418 |
| Cairo, Ill......... | 6- 7-00 | 2.04 | 3 | 421 |
| St. Paul, Minn... | 6-12-99 | 2.04 | 2 | 423 |
| New Orleans, La.. | 7- 4-03 | 2.04 | 1 | 424 |
| Yankton, S. D.... | 7-15-00 | 2.04 | 3 | 427 |
| Springfield, Mo... | 6-24-06 | 2.03 | 10 | 437 |
| Columbus, O...... | 7-28-02 | 2.02 | 1 | 438 |
| Dodge City, Kans.. | 8- 6-98 | 2.02 | 3 | 441 |
| Columbia, Mo..... | 9-18-04 | 2.02 | 5 | 446 |
| Kansas City, Mo... | 5-23-02 | 2.02 | 7 | 453 |
| New Orleans, La.. | 7-15-01 | 2.01 | 1 | 454 |
| Wichita, Kans..... | 5-20-03 | 2.00 | 10 | 464 |
| Lincoln, Neb..... | 5-28-05 | 2.00 | 6 | 470 |
| Evansville, Ind... | 5-30-00 | 2.00 | 4 | 474 |
| La Crosse, Wis.... | 8- 4-05 | 1.98 | 5 | 479 |
| Yankton, S. D.... | 7-14-00 | 1.96 | 3 | 482 |
| Memphis, Tenn.... | 11-19-06 | 1.96 | 3 | 485 |
| Nashville Tenn.... | 6- 7-00 | 1.95 | 2 | 487 |
| Hannibal, Mo..... | 6- 4-04 | 1.95 | 5 | 492 |
| Lincoln, Neb..... | 7-15-00 | 1.95 | 6 | 498 |
| Ft. Worth, Tex... | 6-24-03 | 1.94 | 3 | 501 |
| Valentine, Neb.... | 6-27-05 | 1.94 | 3 | 504 |
| Indianapolis, Ind.. | 8- 2-99 | 1.93 | 2 | 506 |
| Yankton, S. D.... | 7-10-07 | 1.92 | 3 | 509 |
| New Orleans, La.. | 8- 3-02 | 1.92 | 1 | 510 |
| St. Paul, Minn.... | 10- 3-03 | 1.92 | 2 | 512 |
| New Orleans, La.. | 4-17-00 | 1.91 | 1 | 513 |
| Kansas City, Mo.. | 6-22-01 | 1.90 | 7 | 520 |
| New Orleans, La.. | 11-22-01 | 1.90 | 1 | 521 |
| Evansville, Ind.... | 7-11-04 | 1.90 | 4 | 525 |
| Hannibal, Mo..... | 9-25-98 | 1.89 | 5 | 530 |
| Indianapolis, Ind.. | 8-19-06 | 1.89 | 2 | 532 |
| New Orleans, La.. | 7-17-97 | 1.88 | 1 | 533 |
| Ft. Worth, Tex... | 7-28-06 | 1.88 | 3 | 536 |
| Yankton, S. D.... | 5-24-06 | 1.88 | 3 | 539 |

| City. | Date. | Av. Rate per hr. | Final Wt. | Partial Tls. |
|---|---|---|---|---|
| Oklahoma City Okla. ......... | 8-28-00 | 1.87 | 4 | 543 |
| Huron, S. D...... | 6-24-02 | 1.86 | 2 | 545 |
| Topeka, Kans..... | 9-22-02 | 1.85 | 7 | 552 |
| Louisville, Ky.... | 7-10-97 | 1.84 | 2 | 554 |
| Columbus, O...... | 7-19-00 | 1.84 | 1 | 555 |
| Nashville, Tenn... | 7-11-97 | 1.84 | 2 | 557 |
| Columbia, Mo..... | 10- 6-00 | 1.84 | 5 | 562 |
| Lincoln, Neb..... | 8- 7-07 | 1.84 | 6 | 568 |
| Lincoln, Neb..... | 7-22-02 | 1.84 | 6 | 574 |
| St. Paul, Minn.... | 9- 5-04 | 1.84 | 2 | 576 |
| Kansas City, Mo... | 9- 5-98 | 1.84 | 7 | 583 |
| Davenport, Ia..... | 9-14-03 | 1.84 | 7 | 590 |
| Des Moines, Ia.... | 4-22-97 | 1.83 | 5 | 595 |
| Omaha, Neb...... | 6-26-06 | 1.82 | 5 | 600 |
| New Orleans, La.. | 8-12-06 | 1.82 | 1 | 601 |
| Ft. Worth, Tex.... | 8-11-06 | 1.82 | 3 | 604 |
| Cincinnati, O..... | 8- 3-00 | 1.81 | 1 | 605 |
| Chicago, Ill....... | 7-28-06 | 1.80 | 2 | 607 |
| St. Paul, Minn.... | 7-25-97 | 1.80 | 2 | 609 |
| New Orleans, La.. | 6- 7-04 | 1.80 | 1 | 610 |
| Topeka, Kans..... | 8- 4-06 | 1.80 | 7 | 617 |
| Little Rock, Ark.. | 4-24-05 | 1.78 | 3 | 620 |
| New Orleans, La.. | 6-20-00 | 1.78 | 1 | 621 |
| Little Rock, Ark.. | 7-29-00 | 1.78 | 3 | 624 |
| Hannibal, Mo..... | 7- 7-98 | 1.76 | 5 | 629 |
| Huron, S. D..... | 8- 8-01 | 1.76 | 2 | 631 |
| Oklahoma City Okla. .......... | 8- 7-06 | 1.76 | 4 | 635 |
| Omaha, Neb....... | 7-15-00 | 1.75 | 5 | 640 |
| Indianapolis, Ind.. | 6- 4-06 | 1.75 | 2 | 642 |
| Columbia, Mo..... | 4-24-04 | 1.74 | 5 | 647 |
| Wichita, Kans.... | 6- 2-04 | 1.74 | 10 | 657 |
| St. Louis, Mo..... | 7-29-03 | 1.73 | 4 | 661 |
| Dodge City, Kans.. | 5-13-98 | 1.72 | 3 | 664 |
| New Orleans, La.. | 3-19-05 | 1.72 | 1 | 665 |
| Nashville, Tenn... | 6-27-04 | 1.72 | 2 | 667 |
| Shreveport, La.... | 4- 2-05 | 1.72 | 4 | 671 |
| Shreveport, La.... | 5-21-05 | 1.72 | 4 | 675 |
| Huron, S. D...... | 8-18-04 | 1.71 | 2 | 677 |
| Bismarck, N. D... | 6-13-01 | 1.71 | 1 | 678 |
| Kansas City, Mo... | 7- 7-02 | 1.71 | 7 | 685 |
| Columbus, O..... | 6-14-04 | 1.71 | 1 | 686 |
| Shreveport, La.... | 7-23-02 | 1.70 | 4 | 690 |
| Columbia, Mo..... | 7-18-02 | 1.68 | 5 | 695 |
| Dodge City, Kans.. | 8- 6-03 | 1.68 | 3 | 698 |
| Springfield, Mo.... | 8- 7-06 | 1.68 | 10 | 708 |
| Ft. Worth, Tex... | 5- 3-04 | 1.68 | 3 | 711 |
| Cairo, Ill......... | 7-30-01 | 1.68 | 3 | 714 |
| Dubuque, Ia. .... | 9-25-04 | 1.68 | 5 | 719 |
| Des Moines, Ia.... | 7-19-04 | 1.66 | 5 | 724 |
| Little Rock, Ark... | 8-25-99 | 1.66 | 3 | 727 |
| Indianapolis, Ind.. | 7- 6-04 | 1.65 | 2 | 729 |
| New Orleans, La.. | 9- 9-98 | 1.65 | 1 | 730 |
| Oklahoma City Okla. ......... | 8-12-01 | 1.64 | 4 | 734 |
| Springfield, Mo.... | 6- 4-04 | 1.64 | 10 | 744 |
| Lexington, Ky.... | 7-19-02 | 1.63 | 1 | 745 |
| Des Moines, Ia... | 7-19-05 | 1.62 | 5 | 750 |
| Memphis, Tenn... | 8-18-01 | 1.62 | 3 | 753 |
| St. Paul, Minn.... | 8- 5-98 | 1.62 | 2 | 755 |
| Nashville, Tenn... | 9-14-01 | 1.61 | 2 | 757 |
| Oklahoma City Okla. ......... | 5-28-03 | 1.60 | 4 | 761 |
| Columbia, Mo..... | 10-28-00 | 1.60 | 5 | 766 |
| Des Moines, Ia.... | 7-16-07 | 1.60 | 5 | 771 |
| Chicago, Ill....... | 5-24-02 | 1.59 | 2 | 773 |
| New Orleans, La.. | 7-18-00 | 1.59 | 1 | 774 |
| Dodge City, Kans.. | 7-28-00 | 1.58 | 3 | 777 |
| Cincinnati, O..... | 7-21-03 | 1.58 | 1 | 778 |
| Hannibal, Mo..... | 8- 8-99 | 1.56 | 5 | 783 |
| Columbia, Mo..... | 10-16-05 | 1.56 | 5 | 788 |
| Louisville, Ky..... | 3-16-98 | 1.55 | 2 | 790 |
| Omaha, Neb...... | 8-26-03 | 1.54 | 5 | 795 |
| Lincoln, Neb...... | 8- 4-02 | 1.54 | 6 | 801 |
| Ft. Smith, Ark.... | 9- 2-06 | 1.54 | 7 | 808 |

| City. | Date. | Av. Rate per hr. | Final Wt. | Partial Tls. |
|---|---|---|---|---|
| Bismarck, N. D. | 6-4-05 | 1.53 | 1 | 809 |
| Indianapolis, Ind. | 5-29-00 | 1.53 | 2 | 811 |
| Bismarck, N. D. | 6-16-97 | 1.53 | 1 | 812 |
| Louisville, Ky. | 6-15-02 | 1.52 | 2 | 814 |
| Columbus, O. | 8-15-00 | 1.52 | 1 | 815 |
| St. Louis, Mo. | 5-5-00 | 1.51 | 4 | 819 |
| New Orleans, La. | 11-9-98 | 1.51 | 1 | 820 |
| Kansas City, Mo. | 9-6-05 | 1.50 | 7 | 827 |
| New Orleans, La. | 7-5-02 | 1.50 | 1 | 828 |
| St. Paul, Minn. | 10-3-00 | 1.50 | 2 | 830 |
| St. Louis, Mo. | 5-21-98 | 1.49 | 4 | 834 |
| New Orleans, La. | 7-25-99 | 1.49 | 1 | 835 |
| Topeka, Kans. | 7-31-02 | 1.48 | 7 | 842 |
| Columbia, Mo. | 6-7-98 | 1.48 | 5 | 847 |
| Memphis, Tenn. | 3-26-02 | 1.48 | 3 | 850 |
| Oklahoma City Okla. | 7-20-97 | 1.46 | 4 | 854 |
| Oklahoma City Okla. | 5-6-00 | 1.46 | 4 | 858 |
| Chicago, Ill. | 7-9-03 | 1.44 | 2 | 860 |
| Omaha, Neb. | 6-16-00 | 1.44 | 5 | 865 |
| Springfield, Ill. | 8-3-05 | 1.44 | 6 | 871 |
| Springfield, Ill. | 6-1-02 | 1.44 | 6 | 877 |
| Kansas City, Mo. | 7-5-04 | 1.44 | 7 | 884 |
| Memphis, Tenn. | 5-26-02 | 1.44 | 3 | 887 |
| Dodge City, Kans. | 10-9-98 | 1.42 | 3 | 890 |
| Lincoln, Neb. | 5-24-03 | 1.42 | 6 | 896 |
| Ft. Worth, Tex. | 9-21-00 | 1.42 | 3 | 899 |
| Ft. Worth, Tex. | 5-24-07 | 1.42 | 3 | 902 |
| Lincoln, Neb. | 9-14-06 | 1.42 | 6 | 908 |
| Des Moines, Ia. | 7-23-00 | 1.40 | 5 | 913 |
| Oklahoma City Okla. | 9-11-06 | 1.40 | 4 | 917 |
| Yankton, S. D. | 9-20-02 | 1.40 | 3 | 920 |
| Huron, S. D. | 8-4-00 | 1.40 | 2 | 922 |
| Hannibal, Mo. | 8-10-99 | 1.40 | 5 | 927 |
| New Orleans, La. | 10-7-00 | 1.38 | 1 | 928 |
| Lincoln, Neb. | 9-16-06 | 1.37 | 6 | 934 |
| Milwaukee, Wis. | 9-14-03 | 1.34 | 2 | 936 |
| Kansas City, Mo. | 7-19-06 | 1.30 | 7 | 943 |
| St. Paul, Minn. | 8-4-05 | 1.28 | 2 | 945 |
| Little Rock, Ark. | 9-10-99 | 1.26 | 3 | 948 |
| Milwaukee, Wis. | 6-12-99 | 1.25 | 2 | 950 |
| Des Moines, Ia. | 5-21-03 | 1.24 | 5 | 955 |
| Kansas City, Mo. | 8-21-04 | 1.22 | 7 | 962 |
| Little Rock, Ark. | 12-13-01 | 1.14 | 3 | 965 |
| Huron, S. D. | 5-9-05 | 1.09 | 2 | 967 |
| Oklahoma City Okla. | 3-25-02 | 1.06 | 4 | 971 |
| Des Moines, Ia. | 4-17-00 | .93 | 5 | 976 |
| New Orleans, La. | 4-25-07 | .80 | 1 | 977 |

## Table IV.

## HEAVY PRECIPITATIONS.

### 20 minutes.

| City. | Date. | Av. Rate per hr. | Final Wt. | Partial Tls. |
|---|---|---|---|---|
| Kansas City, Mo. | 8-23-06 | 6.48 | 7 | 7 |
| New Orleans, La. | 9-30-05 | 6.07 | 1 | 8 |
| New Orleans, La. | 5-30-07 | 5.16 | 1 | 9 |
| Cincinnati, O. | 5-20-02 | 5.03 | 1 | 10 |
| St. Louis, Mo. | 7-8-98 | 4.92 | 4 | 14 |
| St. Paul, Minn. | 8-9-02 | 4.92 | 2 | 16 |
| Hannibal, Mo. | 8-17-06 | 4.68 | 5 | 21 |
| New Orleans, La. | 8-25-04 | 4.65 | 1 | 22 |
| Milwaukee, Wis. | 6-24-04 | 4.64 | 2 | 24 |
| Nashville, Tenn. | 11-20-00 | 4.60 | 2 | 26 |
| Columbus, O. | 6-23-01 | 4.49 | 1 | 27 |
| Des Moines, Ia. | 7-19-04 | 4.41 | 5 | 32 |
| Omaha, Neb. | 7-6-98 | 4.24 | 5 | 37 |
| Springfield, Mo. | 5-31-06 | 4.24 | 10 | 47 |
| Wichita, Kans. | 9-17-05 | 4.20 | 10 | 57 |
| Ft. Worth, Tex. | 9-21-00 | 4.14 | 3 | 60 |
| Columbus, O. | 7-11-97 | 4.11 | 1 | 61 |
| Columbia, Mo. | 8-22-05 | 4.06 | 5 | 66 |
| Nashville, Tenn. | 8-21-02 | 4.02 | 2 | 68 |
| Davenport, Ia. | 9-1-05 | 4.00 | 7 | 75 |
| Little Rock, Ark. | 7-11-03 | 3.98 | 3 | 78 |
| New Orleans, La. | 7-18-01 | 3.95 | 1 | 79 |
| Springfield, Mo. | 7-26-05 | 3.92 | 10 | 89 |
| Nashville, Tenn. | 6-15-97 | 3.92 | 2 | 91 |
| Columbia, Mo. | 5-31-02 | 3.90 | 11 | 102 |
| Cairo, Ill. | 6-28-05 | 3.84 | 3 | 105 |
| Hannibal, Mo. | 9-9-03 | 3.81 | 5 | 110 |
| Huron, S. D. | 7-6-05 | 3.81 | 2 | 112 |
| Louisville, Ky. | 8-8-98 | 3.80 | 2 | 114 |
| Ft. Worth, Tex. | 6-3-04 | 3.78 | 3 | 117 |
| Columbia, Mo. | 6-25-99 | 3.78 | 5 | 122 |
| New Orleans, La. | 3-17-04 | 3.77 | 1 | 123 |
| Nashville, Tenn. | 7-19-04 | 3.75 | 2 | 125 |
| Ft. Worth, Tex. | 3-25-04 | 3.74 | 3 | 128 |
| Shreveport, La. | 7-23-05 | 3.74 | 4 | 132 |
| Topeka, Kans. | 8-2-03 | 3.72 | 7 | 139 |
| Columbia, Mo. | 8-25-00 | 3.72 | 5 | 144 |
| Wichita, Kans. | 7-6-04 | 3.72 | 10 | 154 |
| Ft. Worth, Tex. | 7-2-05 | 3.70 | 3 | 157 |
| Lincoln, Neb. | 8-15-00 | 3.68 | 6 | 163 |
| Little Rock, Ark. | 5-21-98 | 3.66 | 3 | 166 |
| Memphis, Tenn. | 6-7-05 | 3.64 | 3 | 169 |
| Springfield, Mo. | 8-14-05 | 3.64 | 10 | 179 |
| Oklahoma City Okla. | 6-4-04 | 3.62 | 4 | 183 |
| New Orleans, La. | 4-25-07 | 3.60 | 1 | 184 |
| Indianapolis, Ind. | 7-25-97 | 3.60 | 2 | 186 |
| New Orleans, La. | 7-11-07 | 3.58 | 1 | 187 |
| Cairo, Ill. | 6-13-99 | 3.58 | 3 | 190 |
| Topeka, Kans. | 9-13-01 | 3.56 | 7 | 197 |
| Davenport, Ia. | 7-10-07 | 3.55 | 7 | 204 |
| Des Moines, Ia. | 5-28-00 | 3.54 | 5 | 209 |
| Huron, S. D. | 6-14-01 | 3.54 | 2 | 211 |
| Indianapolis, Ind. | 8-9-99 | 3.52 | 2 | 213 |
| Topeka, Kans. | 6-24-03 | 3.48 | 7 | 220 |
| Kansas City, Mo. | 6-22-06 | 3.46 | 7 | 227 |
| Cincinnati, O. | 7-22-06 | 3.43 | 1 | 228 |
| Denver, Colo. | 5-27-98 | 3.42 | 1 | 229 |
| New Orleans, La. | 8-22-03 | 3.42 | 1 | 230 |
| Kansas City, Mo. | 9-14-05 | 3.40 | 7 | 237 |
| New Orleans, La. | 7-15-01 | 3.40 | 1 | 238 |
| St. Louis, Mo. | 8-6-07 | 3.40 | 4 | 242 |
| Oklahoma City Okla. | 5-29-05 | 3.38 | 4 | 246 |
| Nashville, Tenn. | 6-15-05 | 3.38 | 2 | 248 |
| Dodge City, Kans. | 6-7-99 | 3.38 | 3 | 251 |
| Davenport, Ia. | 7-10-07 | 3.36 | 7 | 258 |
| New Orleans, La. | 4-17-01 | 3.36 | 1 | 259 |
| Des Moines, Ia. | 7-14-07 | 3.36 | 5 | 264 |
| New Orleans, La. | 7-19-01 | 3.35 | 1 | 265 |
| Columbia, Mo. | 7-2-05 | 3.34 | 5 | 270 |
| Indianapolis, Ind. | 9-30-02 | 3.34 | 2 | 272 |
| Dodge City, Kans. | 6-4-98 | 3.34 | 3 | 275 |
| New Orleans, La. | 3-14-03 | 3.33 | 1 | 276 |
| Topeka, Kans. | 7-21-04 | 3.32 | 7 | 283 |
| Chicago, Ill. | 7-15-06 | 3.30 | 2 | 285 |
| Lexington, Ky. | 8-22-00 | 3.30 | 1 | 286 |
| Louisville, Ky. | 5-31-03 | 3.29 | 2 | 288 |
| Nashville, Tenn. | 9-1-00 | 3.29 | 2 | 290 |
| Dubuque, Ia. | 8-15-07 | 3.28 | 5 | 295 |

(298 weighted rains every 5 years.)

| City. | Date. | Av. Rate per hr. | Final Wt. | Partial Tls. |
|---|---|---|---|---|
| Columbia, Mo..... | 9-16-05 | 3.26 | 5 | 300 |
| Nashville, Tenn... | 6- 7-00 | 3.26 | 2 | 302 |
| St. Louis, Mo.... | 5- 1-99 | 3.25 | 4 | 306 |
| St. Louis, Mo..... | 5- 4-02 | 3.25 | 4 | 310 |
| Little Rock, Ark... | 5- 8-00 | 3.24 | 3 | 313 |
| Huron, S. D...... | 6-12-00 | 3.24 | 2 | 315 |
| Shreveport, La... | 6- 1-06 | 3.24 | 4 | 319 |
| Dodge City, Kas.. | 8- 6-98 | 3.22 | 3 | 322 |
| Milwaukee, Wis... | 9- 2-00 | 3.22 | 2 | 324 |
| New Orleans, La.. | 3-30-99 | 3.22 | 1 | 325 |
| Chicago, Ill....... | 8- 5-05 | 3.20 | 2 | 327 |
| Wichita, Kans..... | 7-14-04 | 3.20 | 10 | 337 |
| Davenport, Ia..... | 9- 1-05 | 3.20 | 7 | 344 |
| St. Louis, Mo..... | 7-24-00 | 3.20 | 4 | 348 |
| Dodge City, Kans.. | 8-18-04 | 3.20 | 3 | 351 |
| Lincoln, Neb...... | 8-17-97 | 3.19 | 6 | 357 |
| Shreveport, La.... | 4-11-05 | 3.18 | 4 | 361 |
| Des Moines, Ia.... | 7-19-05 | 3.18 | 5 | 366 |
| St. Louis, Mo.... | 6-13-00 | 3.18 | 4 | 370 |
| Indianapolis, Ind.. | 8-19-01 | 3.18 | 2 | 372 |
| New Orleans, La.. | 7-11-04 | 3.17 | 1 | 373 |
| New Orleans, La.. | 12-22-07 | 3.17 | 1 | 374 |
| New Orleans, La.. | 8-22-03 | 3.16 | 1 | 375 |
| Springfield, Ill.... | 8- 7-07 | 3.16 | 6 | 381 |
| Little Rock, Ark... | 9-15-98 | 3.16 | 3 | 384 |
| Lincoln, Neb...... | 7-15-00 | 3.16 | 6 | 390 |
| Denver, Colo...... | 9-20-02 | 3.16 | 1 | 391 |
| New Orleans, La.. | 3-14-03 | 3.15 | 1 | 392 |
| Cairo, Ill.......... | 8- 7-06 | 3.14 | 3 | 395 |
| Evansville, Ind.... | 9- 2-00 | 3.14 | 4 | 399 |
| New Orleans, La.. | 7-10-07 | 3.14 | 1 | 400 |
| Nashville, Tenn... | 6-28-00 | 3.13 | 2 | 402 |
| Lincoln, Neb..... | 4-23-97 | 3.12 | 6 | 408 |
| New Orleans, La.. | 7- 6-04 | 3.11 | 1 | 409 |
| Yankton, S. D.... | 7-15-00 | 3.10 | 3 | 412 |
| Hannibal, Mo..... | 8-13-04 | 3.10 | 5 | 417 |
| New Orleans, La.. | 6-22-03 | 3.10 | 1 | 418 |
| St. Paul, Minn.... | 10- 3-03 | 3.10 | 2 | 420 |
| Huron, S. D...... | 6-27-05 | 3.10 | 2 | 422 |
| Ft. Worth, Tex.... | 6- 5-07 | 3.10 | 3 | 425 |
| Wichita, Kans.... | 8- 1-03 | 3.10 | 10 | 435 |
| Hannibal, Mo..... | 9- 4-98 | 3.09 | 5 | 440 |
| Ft. Worth, Tex... | 6-20-06 | 3.08 | 3 | 443 |
| Oklahoma City Okla. ......... | 9-11-06 | 3.08 | 4 | 447 |
| Lexington, Ky..... | 7-28-04 | 3.08 | 1 | 448 |
| Dodge City, Kans.. | 6-17-06 | 3.08 | 3 | 451 |
| Nashville, Tenn... | 9- 4-06 | 3.07 | 2 | 453 |
| Evansville, Ind.... | 5- 8-00 | 3.06 | 4 | 457 |
| Ft. Worth, Tex... | 7-28-06 | 3.06 | 3 | 460 |
| New Orleans, La.. | 8-24-03 | 3.06 | 1 | 461 |
| Memphis, Tenn.... | 8- 9-05 | 3.06 | 3 | 464 |
| Ft. Worth, Tex... | 5- 2-06 | 3.04 | 3 | 467 |
| Huron, S. D...... | 8- 8-04 | 3.04 | 2 | 469 |
| New Orleans, La.. | 6- 4-05 | 3.03 | 1 | 470 |
| Wichita, Kans..... | 6-15-05 | 3.00 | 10 | 480 |
| Memphis, Tenn.... | 3- 9-01 | 3.00 | 2 | 482 |
| Yankton, S. D..... | 8-23-06 | 3.00 | 3 | 485 |
| Little Rock, Ark... | 5-12-05 | 2.98 | 3 | 488 |
| St. Paul, Minn.... | 6-28-01 | 2.98 | 2 | 490 |
| Lexington, Ky.... | 8-23-05 | 2.98 | 1 | 491 |
| Bismarck, N. D... | 6-13-01 | 2.97 | 1 | 492 |
| Yankton, S. D.... | 7-14-00 | 2.96 | 3 | 495 |
| Oklahoma City Okla. ......... | 5- 5-99 | 2.96 | 4 | 499 |
| Kansas City, Mo... | 5-24-05 | 2.96 | 7 | 506 |
| Kansas City, Mo... | 8- 2-05 | 2.96 | 7 | 513 |
| Chicago, Ill...... | 7-28-06 | 2.96 | 2 | 515 |
| Evansville, Ind... | 8- 5-03 | 2.96 | 4 | 519 |
| Lincoln, Neb..... | 7-31-03 | 2.96 | 6 | 525 |
| La Crosse, Wis... | 7- 9-03 | 2.96 | 5 | 530 |
| Nashville, Tenn... | 7-10-97 | 2.95 | 2 | 532 |
| Huron, S. D...... | 7-20-07 | 2.95 | 2 | 534 |
| St. Louis, Mo..... | 7- 4-99 | 2.94 | 4 | 538 |
| New Orleans, La.. | 8-25-03 | 2.94 | 1 | 539 |
| Chicago, Ill...... | 7- 1-01 | 2.92 | 2 | 541 |

| City. | Date. | Av. Rate per hr. | Final Wt. | Partial Tls. |
|---|---|---|---|---|
| Hannibal, Mo..... | 9-25-98 | 2.92 | 5 | 546 |
| Bismarck, N. D... | 6-16-97 | 2.92 | 1 | 547 |
| Evansville, Ind... | 7-20-04 | 2.92 | 4 | 551 |
| Indianapolis, Ind.. | 3-31-04 | 2.92 | 2 | 553 |
| Davenport, Ia..... | 9-25-04 | 2.91 | 7 | 560 |
| New Orleans, La.. | 8- 5-07 | 2.91 | 1 | 561 |
| Ft. Worth, Tex... | 5-11-05 | 2.90 | 3 | 564 |
| St. Paul, Minn.... | 9-25-06 | 2.90 | 2 | 566 |
| Yankton, S. D.... | 8-18-99 | 2.90 | 3 | 569 |
| New Orleans, La.. | 9-16-01 | 2.90 | 1 | 570 |
| Evansville, Ind... | 9- 2-04 | 2.90 | 4 | 574 |
| Denver, Colo..... | 6- 2-00 | 2.88 | 1 | 575 |
| Hannibal, Mo..... | 5-26-06 | 2.88 | 5 | 580 |
| Little Rock, Ark.. | 11-28-05 | 2.88 | 3 | 583 |
| Dodge City, Kans. | 7-23-99 | 2.88 | 3 | 586 |
| Columbus, O..... | 7-28-02 | 2.88 | 1 | 587 |
| Evansville, Ind... | 8-14-06 | 2.86 | 4 | 591 |
| Hannibal, Mo.... | 8- 8-99 | 2.86 | 5 | 596 |
| Dodge City, Kans.. | 6- 7-99 | 2.86 | 3 | 599 |
| St. Paul, Minn... | 9- 5-04 | 2.86 | 2 | 601 |
| Omaha, Neb....... | 7-18-07 | 2.85 | 5 | 606 |
| Valentine, Neb.... | 7-21-04 | 2.84 | 3 | 609 |
| Shreveport, La.... | 7-23-02 | 2.84 | 4 | 613 |
| New Orleans, La.. | 8- 5-98 | 2.84 | 1 | 614 |
| Columbia, Mo..... | 6-14-98 | 2.83 | 5 | 619 |
| Chicago, Ill....... | 5-11-05 | 2.82 | 2 | 621 |
| Shreveport, La... | 6-27-02 | 2.82 | 4 | 625 |
| Oklahoma City Okla. ......... | 8-28-00 | 2.81 | 4 | 629 |
| Dodge City, Kans.. | 7-19-97 | 2.80 | 3 | 632 |
| Memphis, Tenn.... | 6-23-99 | 2.80 | 3 | 635 |
| Columbia, Mo..... | 7-31-99 | 2.80 | 5 | 641 |
| Columbia, Mo..... | 9-18-04 | 2.80 | 5 | 646 |
| Topeka, Kans..... | 7-28-01 | 2.79 | 7 | 653 |
| Springfield, Mo.... | 7-19-06 | 2.79 | 10 | 663 |
| Indianapolis, Ind.. | 8-12-00 | 2.78 | 2 | 665 |
| Kansas City, Mo... | 8-21-04 | 2.78 | 7 | 672 |
| Columbus, O...... | 6-14-04 | 2.77 | 1 | 673 |
| Huron, S. D....... | 8- 8-01 | 2.77 | 2 | 675 |
| New Orleans, La.. | 4-25-07 | 2.77 | 1 | 676 |
| Kansas City, Mo... | 5-23-02 | 2.76 | 7 | 683 |
| New Orleans, La.. | 6-27-04 | 2.76 | 1 | 684 |
| Lincoln, Neb...... | 5-28-05 | 2.75 | 6 | 690 |
| Nashville, Tenn... | 6- 9-03 | 2.75 | 2 | 692 |
| Shreveport, La.... | 5- 3-06 | 2.75 | 4 | 696 |
| Ft. Worth, Tex.... | 6-24-03 | 2.74 | 3 | 699 |
| Little Rock, Ark... | 6- 1-98 | 2.74 | 3 | 702 |
| Kansas City, Mo.. | 7-14-07 | 2.74 | 7 | 709 |
| Huron, S. D...... | 6-24-02 | 2.74 | 2 | 711 |
| Dodge City, Kans.. | 8-16-07 | 2.74 | 3 | 714 |
| New Orleans, La.. | 6- 7-04 | 2.74 | 1 | 715 |
| Omaha, Neb....... | 6-26-06 | 2.74 | 5 | 720 |
| New Orleans, La.. | 3-14-03 | 2.74 | 1 | 721 |
| Indianapolis, Ind.. | 8-19-06 | 2.73 | 2 | 723 |
| New Orleans, La.. | 7-11-06 | 2.71 | 1 | 724 |
| Topeka, Kans..... | 8-26-02 | 2.71 | 7 | 731 |
| Hannibal, Mo..... | 6- 4-04 | 2.70 | 5 | 736 |
| Valentine, Neb.... | 7- 6-07 | 2.70 | 3 | 739 |
| Lincoln, Neb...... | 8- 4-07 | 2.70 | 6 | 745 |
| Kansas City, Mo... | 7- 2-05 | 2.70 | 7 | 752 |
| Wichita, Kans.... | 5-20-03 | 2.68 | 10 | 762 |
| Kansas City, Mo.. | 6-22-01 | 2.68 | 7 | 769 |
| New Orleans, La.. | 8-12-06 | 2.68 | 1 | 770 |
| Louisville, Ky..... | 7-10-97 | 2.68 | 2 | 772 |
| New Orleans, La.. | 6-20-00 | 2.68 | 1 | 773 |
| New Orleans, La.. | 7- 4-03 | 2.67 | 1 | 774 |
| St. Paul, Minn.... | 6-14-01 | 2.66 | 2 | 776 |
| Shreveport, La.... | 5-21-05 | 2.66 | 4 | 780 |
| Milwaukee, Wis... | 8-23-98 | 2.65 | 2 | 782 |
| Indianapolis, Ind.. | 7- 6-04 | 2.64 | 2 | 784 |
| Davenport, Ia..... | 9- 9-03 | 2.64 | 7 | 791 |
| Yankton, S. D..... | 7-10-07 | 2.64 | 3 | 794 |
| Bismarck, N. D... | 10- 1-98 | 2.63 | 1 | 795 |
| Lexington, Ky..... | 5-10-05 | 2.63 | 1 | 796 |
| Dodge City, Kans.. | 7-21-07 | 2.62 | 3 | 799 |
| New Orleans, La.. | 4-17-00 | 2.62 | 1 | 800 |

| City. | Date. | Av. Rate per hr. | Final Wt. | Partial Tls. |
|---|---|---|---|---|
| Valentine, Neb. | 6-27-05 | 2.62 | 3 | 803 |
| La Crosse, Wis. | 7-21-07 | 2.62 | 5 | 808 |
| Wichita, Kans. | 6- 2-04 | 2.62 | 10 | 818 |
| St. Louis, Mo. | 5-21-98 | 2.62 | 4 | 822 |
| Wichita, Kans. | 8-16-07 | 2.61 | 10 | 832 |
| Kansas City, Mo. | 8-15-03 | 2.61 | 7 | 839 |
| Oklahoma City Okla. | 5- 6-99 | 2.61 | 4 | 843 |
| Nashville, Tenn. | 7-11-97 | 2.61 | 2 | 845 |
| Evansville, Ind. | 7-11-04 | 2.60 | 4 | 849 |
| St. Louis, Mo. | 5-31-03 | 2.60 | 4 | 853 |
| Memphis, Tenn. | 8-30-97 | 2.60 | 3 | 856 |
| Indianapolis, Ind. | 8- 2-99 | 2.60 | 2 | 858 |
| Wichita, Kans. | 6- 2-05 | 2.59 | 10 | 868 |
| Oklahoma City Okla. | 5-28-03 | 2.58 | 4 | 872 |
| Ft. Smith, Ark. | 8-26-04 | 2.58 | 7 | 879 |
| Little Rock, Ark. | 7-29-00 | 2.58 | 3 | 882 |
| Davenport, Ia. | 9-14-03 | 2.58 | 7 | 889 |
| St. Paul, Minn. | 8- 5-98 | 2.58 | 2 | 891 |
| Des Moines, Ia. | 4-22-97 | 2.57 | 5 | 896 |
| Kansas City, Mo. | 7- 7-02 | 2.57 | 7 | 903 |
| Kansas City, Mo. | 3-24-04 | 2.56 | 7 | 910 |
| Hannibal, Mo. | 7- 4-99 | 2.56 | 5 | 915 |
| Springfield, Ill. | 5- 5-01 | 2.56 | 6 | 921 |
| Columbia, Mo. | 5-25-03 | 2.56 | 5 | 926 |
| Kansas City, Mo. | 9- 5-98 | 2.56 | 7 | 933 |
| Cairo, Ill. | 6- 7-00 | 2.56 | 3 | 936 |
| Ft. Worth, Tex. | 5- 3-04 | 2.54 | 3 | 939 |
| Lexington, Ky. | 7-19-02 | 2.54 | 1 | 940 |
| Shreveport, La. | 4- 2-05 | 2.54 | 4 | 944 |
| Bismarck, N. D. | 6- 4-05 | 2.54 | 1 | 945 |
| Columbia, Mo. | 10-16-05 | 2.53 | 5 | 950 |
| Columbia, Mo. | 4-25-02 | 2.52 | 5 | 955 |
| Lincoln, Neb. | 7-22-02 | 2.52 | 6 | 961 |
| Evansville, Ind. | 7-10-05 | 2.52 | 4 | 965 |
| New Orleans, La. | 3-19-05 | 2.50 | 1 | 966 |
| Memphis, Tenn. | 11-19-06 | 2.50 | 3 | 969 |
| Cincinnati, O. | 5-29-99 | 2.50 | 1 | 970 |
| Memphis, Tenn. | 8-18-01 | 2.48 | 3 | 973 |
| New Orleans, La. | 7- 7-98 | 2.48 | 1 | 974 |
| Evansville, Ind. | 6- 2-04 | 2.48 | 4 | 978 |
| Columbus, O. | 7-20-97 | 2.48 | 1 | 979 |
| Kansas City, Mo. | 9- 9-03 | 2.48 | 7 | 986 |
| New Orleans, La. | 11-22-01 | 2.48 | 1 | 987 |
| Oklahoma City Okla. | 8-11-02 | 2.46 | 4 | 991 |
| Cincinnati, O. | 8- 3-00 | 2.46 | 1 | 992 |
| Milwaukee, Wis. | 7-21-07 | 2.46 | 2 | 994 |
| Little Rock, Ark. | 8-25-99 | 2.46 | 3 | 997 |
| Little Rock, Ark. | 6-22-04 | 2.46 | 3 | 1000 |
| Springfield, Mo. | 6- 4-04 | 2.45 | 10 | 1010 |
| New Orleans, La. | 5-23-07 | 2.45 | 1 | 1011 |
| Columbia, Mo. | 10-28-00 | 2.44 | 5 | 1016 |
| Lincoln, Neb. | 8- 4-02 | 2.44 | 6 | 1022 |
| Topeka, Kans. | 9-22-02 | 2.42 | 7 | 1029 |
| Oklahoma City Okla. | 5-23-03 | 2.42 | 4 | 1033 |
| Oklahoma City Okla. | 8- 7-06 | 2.42 | 4 | 1037 |
| Ft. Worth, Tex. | 10-21-00 | 2.42 | 3 | 1040 |
| St. Paul, Minn. | 8-18-07 | 2.42 | 2 | 1042 |
| Evansville, Ind. | 5-30-00 | 2.42 | 4 | 1046 |
| Cairo, Ill. | 6-22-97 | 2.42 | 3 | 1049 |
| Little Rock, Ark. | 4-24-05 | 2.40 | 3 | 1052 |
| Springfield, Ill. | 6- 1-02 | 2.40 | 5 | 1057 |
| St. Louis, Mo. | 7-29-03 | 2.40 | 4 | 1061 |
| St. Louis, Mo. | 5- 5-00 | 2.39 | 4 | 1065 |
| Wichita, Kans. | 10-30-03 | 2.38 | 10 | 1075 |
| Columbia, Mo. | 10- 6-00 | 2.37 | 5 | 1080 |
| Valentine, Neb. | 7-11-06 | 2.36 | 3 | 1083 |
| Ft. Worth, Tex. | 8-11-06 | 2.36 | 3 | 1086 |
| New Orleans, La. | 8- 3-02 | 2.34 | 1 | 1087 |
| Kansas City, Mo. | 9- 6-05 | 2.34 | 7 | 1094 |
| St. Paul, Minn. | 7-30-04 | 2.32 | 2 | 1096 |
| Kansas City, Mo. | 7-19-06 | 2.32 | 7 | 1103 |
| Yankton, S. D. | 5-24-06 | 2.32 | 3 | 1106 |
| Omaha, Neb. | 7-15-00 | 2.32 | 5 | 1111 |
| Valentine, Neb. | 7- 9-07 | 2.32 | 3 | 1114 |
| Shreveport, La. | 5- 7-07 | 2.32 | 4 | 1118 |
| Springfield, Mo. | 6-24-06 | 2.31 | 10 | 1128 |
| New Orleans, La. | 7-18-00 | 2.31 | 1 | 1129 |
| Evansville, Ind. | 5-31-07 | 2.30 | 4 | 1133 |
| Columbia, Mo. | 7-18-02 | 2.30 | 5 | 1138 |
| Little Rock, Ark. | 9-10-99 | 2.30 | 3 | 1141 |
| New Orleans, La. | 7-17-97 | 2.29 | 1 | 1142 |
| Lincoln, Neb. | 9-14-06 | 2.28 | 6 | 1148 |
| Yankton, S. D. | 9-20-02 | 2.28 | 3 | 1151 |
| Columbus, O. | 7-19-00 | 2.28 | 1 | 1152 |
| Nashville, Tenn. | 6-27-04 | 2.28 | 2 | 1154 |
| Omaha, Neb. | 6-16-00 | 2.26 | 5 | 1159 |
| Chicago, Ill. | 5-24-02 | 2.26 | 2 | 1161 |
| Des Moines, Ia. | 7-23-00 | 2.25 | 5 | 1166 |
| Dodge City, Kans. | 10- 9-98 | 2.24 | 3 | 1169 |
| Hannibal, Mo. | 8- 8-99 | 2.24 | 5 | 1174 |
| Lincoln, Neb. | 8- 7-07 | 2.24 | 6 | 1180 |
| Indianapolis, Ind. | 5-29-00 | 2.23 | 2 | 1182 |
| New Orleans, La. | 8- 3-98 | 2.23 | 1 | 1183 |
| St. Paul, Minn. | 6-12-99 | 2.22 | 2 | 1185 |
| Oklahoma City Okla. | 3-25-02 | 2.22 | 4 | 1189 |
| Des Moines, Ia. | 4-17-00 | 2.21 | 5 | 1194 |
| New Orleans, La. | 9- 9-98 | 2.18 | 1 | 1195 |
| Dubuque, Ia. | 9-25-04 | 2.18 | 5 | 1200 |
| St. Paul, Minn. | 8- 4-05 | 2.18 | 2 | 1202 |
| Des Moines, Ia. | 7-16-07 | 2.18 | 5 | 1207 |
| New Orleans, La. | 7-25-99 | 2.17 | 1 | 1208 |
| Des Moines, Ia. | 7-18-04 | 2.17 | 5 | 1213 |
| Columbia, Mo. | 4-24-04 | 2.16 | 5 | 1218 |
| La Crosse, Wis. | 8- 4-05 | 2.14 | 5 | 1223 |
| Topeka, Kans. | 7-31-02 | 2.12 | 7 | 1230 |
| Cincinnati, O. | 7-21-03 | 2.12 | 1 | 1231 |
| Chicago, Ill. | 7- 9-03 | 2.12 | 2 | 1233 |
| Louisville, Ky. | 6-15-02 | 2.12 | 2 | 1235 |
| Yankton, S. D. | 9-20-02 | 2.08 | 3 | 1238 |
| St. Paul, Minn. | 10- 3-00 | 2.08 | 2 | 1240 |
| Huron, S. D. | 8-18-04 | 2.07 | 2 | 1242 |
| Oklahoma City Okla. | 5- 6-00 | 2.05 | 4 | 1246 |
| Cairo, Ill. | 7-30-01 | 2.04 | 3 | 1249 |
| Dodge City, Kans. | 7-28-00 | 2.02 | 3 | 1252 |
| Oklahoma City Okla. | 8-12-01 | 2.00 | 4 | 1256 |
| Springfield, Ill. | 8- 3-05 | 2.00 | 6 | 1262 |
| Springfield, Mo. | 8- 7-06 | 2.00 | 10 | 1272 |
| Columbia, Mo. | 6- 7-98 | 1.98 | 5 | 1277 |
| Indianapolis, Ind. | 6- 4-06 | 1.97 | 2 | 1279 |
| Ft. Worth, Tex. | 9-21-00 | 1.96 | 3 | 1282 |
| St. Paul, Minn. | 7-25-97 | 1.94 | 2 | 1284 |
| Little Rock, Ark. | 7-29-03 | 1.94 | 3 | 1287 |
| Topeka, Kans. | 8- 4-06 | 1.93 | 7 | 1294 |
| Omaha, Neb. | 8-26-03 | 1.92 | 5 | 1299 |
| Kansas City, Mo. | 7- 5-04 | 1.92 | 7 | 1306 |
| New Orleans, La. | 11- 9-98 | 1.90 | 1 | 1307 |
| Oklahoma City Okla. | 5-21-03 | 1.90 | 4 | 1311 |
| Milwaukee, Wis. | 6-12-99 | 1.90 | 2 | 1313 |
| Ft. Worth, Tex. | 5-24-07 | 1.86 | 3 | 1316 |
| Huron, S. D. | 8- 4-00 | 1.85 | 2 | 1318 |
| Des Moines, Ia. | 5-21-03 | 1.84 | 5 | 1323 |
| Ft. Smith, Ark. | 9- 2-06 | 1.82 | 7 | 1330 |
| Nashville, Tenn. | 9-14-01 | 1.80 | 2 | 1332 |
| Dodge City, Kans. | 8- 6-03 | 1.80 | 3 | 1335 |
| Hannibal, Mo. | 7- 7-98 | 1.76 | 5 | 1340 |
| New Orleans, La. | 10- 7-00 | 1.76 | 1 | 1341 |
| Lincoln, Neb. | 5-10-05 | 1.76 | 6 | 1347 |
| Dodge City, Kans. | 5-13-98 | 1.72 | 3 | 1350 |
| Columbus, O. | 8-15-00 | 1.72 | 1 | 1351 |
| Hannibal, Mo. | 8-10-99 | 1.64 | 5 | 1356 |
| New Orleans, La. | 7- 5-02 | 1.63 | 1 | 1357 |
| Louisville, Ky. | 3-16-98 | 1.60 | 2 | 1359 |
| Huron, S. D. | 5- 9-05 | 1.58 | 2 | 1361 |

| City. | Date. | Av. Rate per hr. | Final Wt. | Partial Tls. |
|---|---|---|---|---|
| Lincoln, Neb..... | 5-24-03 | 1.55 | 6 | 1367 |
| Oklahoma City Okla. ......... | 7-20-97 | 1.44 | 4 | 1371 |
| Little Rock, Ark.. | 12-31-01 | 1.44 | 3 | 1374 |
| New Orleans, La.. | 4-25-07 | 1.26 | 1 | 1375 |
| Lincoln, Neb..... | 9-16-06 | 1.10 | 6 | 1381 |

Table V.

## HEAVY PRECIPITATIONS.

10 MINUTES.

| City. | Date. | Av. Rate per hr. | Final Wt. | Partial Tls. |
|---|---|---|---|---|
| Huron, S. D..... | 6-14-01 | 7.34 | 2 | 2 |
| New Orleans, La.. | 9-30-05 | 7.06 | 1 | 3 |
| Kansas City, Mo.. | 8-23-06 | 6.78 | 7 | 10 |
| New Orleans, La.. | 5-30-07 | 6.50 | 1 | 11 |
| Des Moines, Ia... | 7-19-04 | 6.12 | 5 | 16 |
| St. Louis, Mo.... | 7- 8-98 | 6.03 | 4 | 20 |
| Springfield, Mo... | 5-31-06 | 6.01 | 10 | 30 |
| New Orleans, La.. | 8-25-04 | 5.93 | 1 | 31 |
| Indianapolis, Ind. | 9-30-02 | 5.84 | 2 | 33 |
| Milwaukee, Wis... | 6-24-04 | 5.78 | 2 | 35 |
| Hannibal, Mo..... | 8-17-06 | 5.64 | 5 | 40 |
| Columbia, Mo..... | 7- 2-05 | 5.62 | 5 | 45 |
| Cincinnati, O..... | 5-20-02 | 5.61 | 1 | 46 |
| Wichita, Kans.... | 9-17-05 | 5.50 | 10 | 56 |
| Omaha, Neb...... | 7- 6-98 | 5.46 | 5 | 61 |
| Columbus, O...... | 6-23-01 | 5.39 | 1 | 62 |
| Louisville, Ky..... | 5-31-03 | 5.36 | 2 | 64 |
| St. Paul, Minn... | 8- 9-02 | 5.30 | 2 | 66 |
| Memphis, Tenn.... | 3- 9-01 | 5.28 | 3 | 69 |
| Hannibal, Mo..... | 5-26-06 | 5.23 | 5 | 74 |
| Nashville, Tenn... | 11-20-00 | 5.22 | 2 | 76 |
| Milwaukee, Wis... | 9-17-07 | 5.20 | 2 | 78 |
| Denver, Colo...... | 5-27-98 | 5.02 | 1 | 79 |
| Columbia, Mo.... | 6-25-99 | 5.02 | 5 | 84 |
| Hannibal, Mo..... | 9- 4-98 | 4.97 | 5 | 89 |
| Indianapolis, Ind. | 8- 9-99 | 4.96 | 2 | 91 |
| St. Louis, Mo.... | 6-13-00 | 4.94 | 4 | 95 |
| Ft. Worth, Tex... | 9-21-00 | 4.90 | 3 | 98 |
| Davenport, Ia..... | 8-26-07 | 4.89 | 7 | 105 |
| Lincoln, Neb..... | 8-15-00 | 4.82 | 6 | 111 |
| Huron, S. D..... | 7- 6-05 | 4.80 | 2 | 113 |
| New Orleans, La.. | 7-15-01 | 4.80 | 1 | 114 |
| Chicago, Ill...... | 8- 5-05 | 4.76 | 2 | 116 |
| Cairo, Ill......... | 6-28-05 | 4.74 | 3 | 119 |
| Davenport, Ia..... | 6- 9-05 | 4.72 | 7 | 126 |
| Ft. Worth, Tex... | 3-25-04 | 4.72 | 3 | 129 |
| Ft. Worth, Tex... | 7- 2-05 | 4.70 | 3 | 132 |
| Des Moines, Ia... | 7-19-05 | 4.67 | 5 | 137 |
| Columbia, Mo..... | 8-22-05 | 4.64 | 5 | 142 |
| New Orleans, La.. | 3-17-04 | 4.62 | 1 | 143 |
| Nashville, Tenn... | 6-15-97 | 4.61 | 2 | 145 |
| Des Moines, Ia... | 5-28-00 | 4.60 | 5 | 150 |
| Columbus, O..... | 7-11-97 | 4.57 | 1 | 151 |
| New Orleans, La.. | 7-18-01 | 4.57 | 1 | 152 |
| Evansville, Ind... | 8- 5-03 | 4.56 | 4 | 156 |
| Chicago, Ill...... | 7-15-06 | 4.53 | 2 | 161 |
| Ft. Worth, Tex... | 6- 3-04 | 4.52 | 3 | 159 |
| Nashville, Tenn... | 8-21-02 | 4.52 | 2 | 171 |
| Hannibal, Mo..... | 9- 9-03 | 4.51 | 5 | 166 |
| Dodge City, Kans. | 8- 6-98 | 4.50 | 3 | 169 |
| New Orleans, La.. | 4-17-01 | 4.50 | 1 | 172 |
| La Crosse, Wis... | 7- 9-03 | 4.50 | 5 | 177 |
| Columbia, Mo..... | 5-31-02 | 4.49 | 5 | 182 |
| Nashville, Tenn... | 7-10-97 | 4.48 | 2 | 184 |
| Columbia, Mo..... | 8-25-00 | 4.46 | 5 | 189 |
| Nashville, Tenn... | 6-28-00 | 4.45 | 2 | 191 |
| St. Louis, Mo..... | 8- 6-07 | 4.44 | 4 | 195 |
| Columbia, Mo..... | 9-16-05 | 4.42 | 5 | 200 |
| Little Rock, Ark.. | 7-11-03 | 4.42 | 3 | 203 |
| Dodge City, Kans. | 6-17-06 | 4.42 | 3 | 206 |
| New Orleans, La.. | 12-22-07 | 4.41 | 1 | 207 |
| Davenport, Ia..... | 7-10-07 | 4.40 | 7 | 214 |
| Little Rock, Ark.. | 5-21-98 | 4.38 | 3 | 217 |
| New Orleans, La.. | 8-25-03 | 4.38 | 1 | 218 |
| St. Louis, Mo.... | 5- 1-99 | 4.38 | 4 | 222 |
| Springfield, Mo... | 7-26-05 | 4.38 | 10 | 232 |
| Nashville, Tenn... | 7-19-04 | 4.37 | 2 | 234 |
| Yankton, S. D.... | 7-15-00 | 4.36 | 3 | 237 |
| Yankton, S. D.... | 8-18-99 | 4.35 | 3 | 240 |
| Wichita, Kans.... | 7- 6-04 | 4.35 | 10 | 250 |
| Louisville, Ky.... | 8- 8-98 | 4.35 | 2 | 252 |
| New Orleans, La.. | 7- 6-04 | 4.31 | 1 | 253 |
| Lincoln, Neb..... | 7-31-03 | 4.31 | 6 | 259 |
| Nashville, Tenn... | 6-15-05 | 4.30 | 2 | 261 |
| Kansas City, Mo.. | 6-22-06 | 4.30 | 7 | 268 |
| Lincoln, Neb..... | 7-15-00 | 4.28 | 6 | 274 |
| New Orleans, La.. | 3-30-99 | 4.27 | 1 | 275 |
| St. Louis, Mo.... | 5- 4-02 | 4.26 | 4 | 279 |
| Lincoln, Neb..... | 8-17-97 | 4.26 | 6 | 285 |
| Topeka, Kans..... | 9-13-01 | 4.24 | 7 | 292 |
| Hannibal, Mo.... | 8-13-04 | 4.24 | 5 | 297 |
| Ft. Worth, Tex... | 7-28-06 | 4.22 | 3 | 300 |
| Dodge City, Kans. | 6- 4-98 | 4.22 | 3 | 303 |
| Oklahoma City Okla. ......... | 6- 4-04 | 4.18 | 4 | 307 |
| New Orleans, La.. | 6-22-03 | 4.18 | 1 | 308 |
| Little Rock, Ark.. | 5- 8-00 | 4.16 | 3 | 311 |
| Ft. Worth, Tex... | 6-20-06 | 4.16 | 3 | 314 |
| Little Rock, Ark.. | 5-12-05 | 4.14 | 3 | 317 |
| Lexington, Ky.... | 7-28-04 | 4.14 | 1 | 318 |
| Ft. Worth, Tex... | 6- 5-07 | 4.14 | 3 | 321 |
| New Orleans, La.. | 4-25-07 | 4.14 | 1 | 322 |
| Indianapolis, Ind.. | 7-25-97 | 4.13 | 2 | 324 |
| Topeka, Kans.... | 7-21-04 | 4.13 | 7 | 331 |
| Indianapolis, Ind.. | 8-19-01 | 4.12 | 2 | 333 |
| New Orleans, La.. | 7-19-01 | 4.08 | 1 | 334 |
| Valentine, Neb.... | 8- 2-04 | 4.08 | 3 | 337 |
| Cairo, Ill......... | 6-13-99 | 4.06 | 3 | 340 |
| Cincinnati, O..... | 7-22-06 | 4.05 | 1 | 341 |
| Evansville, Ind... | 7-11-04 | 4.04 | 4 | 345 |
| Evansville, Ind... | 5- 8-00 | 4.02 | 4 | 349 |
| Topeka, Kans..... | 8- 2-03 | 4.02 | 7 | 356 |
| New Orleans, La.. | 4-25-07 | 3.99 | 1 | 357 |
| Shreveport, La... | 6- 1-06 | 3.98 | 1 | 358 |
| Bismarck, N. D... | 6-13-01 | 3.98 | 1 | 359 |
| New Orleans, La.. | 7-10-07 | 3.97 | 1 | 360 |
| Davenport, Ia..... | 9-25-04 | 3.96 | 7 | 367 |
| Topeka, Kans.... | 6-24-03 | 3.96 | 7 | 374 |
| Ft. Worth, Tex.. | 5- 2-06 | 3.94 | 3 | 377 |
| Huron, S. D..... | 8- 8-04 | 3.93 | 2 | 379 |
| New Orleans, La.. | 8- 5-07 | 3.92 | 1 | 380 |
| St. Paul, Minn... | 8- 5-98 | 3.92 | 2 | 382 |
| Des Moines, Ia... | 7-14-07 | 3.92 | 5 | 387 |
| Oklahoma City Okla. ......... | 5- 6-00 | 3.92 | 4 | 391 |
| Nashville, Tenn... | 6- 7-00 | 3.91 | 2 | 393 |
| Columbia, Mo..... | 6-14-98 | 3.90 | 5 | 398 |
| Topeka, Kans..... | 9-22-02 | 3.90 | 7 | 405 |
| Dodge City, Kans. | 6- 7-99 | 3.90 | 3 | 408 |
| Columbus, O..... | 6-14-04 | 3.89 | 1 | 409 |
| Little Rock, Ark.. | 9-15-98 | 3.88 | 3 | 412 |
| Dodge City, Kans. | 8-18-04 | 3.88 | 3 | 415 |
| Dodge City, Kans. | 6- 7-99 | 3.88 | 3 | 418 |
| Wichita, Kans..... | 8- 1-03 | 3.88 | 10 | 428 |
| New Orleans, La.. | 3-14-03 | 3.88 | 1 | 429 |
| Cincinnati, O..... | 5-29-99 | 3.87 | 1 | 430 |

| City. | Date. | Av. Rate per hr. | Final Wt. | Partial Tls. |
|---|---|---|---|---|
| Shreveport, La.... | 7-23-05 | 3.86 | 4 | 434 |
| Memphis, Tenn.... | 6- 7-05 | 3.86 | 3 | 437 |
| Cairo, Ill......... | 8- 7-06 | 3.86 | 3 | 440 |
| Indianapolis, Ind.. | 8-12-00 | 3.85 | 2 | 442 |
| New Orleans, La.. | 6-20-00 | 3.84 | 1 | 443 |
| St. Louis, Mo.... | 7-24-00 | 3.84 | 4 | 447 |
| Springfield, Ill.... | 8- 7-07 | 3.83 | 6 | 453 |
| Huron, S. D..... | 7-20-07 | 3.83 | 2 | 455 |
| Chicago, Ill....... | 7-28-06 | 3.82 | 2 | 457 |
| Oklahoma City Okla. .......... | 5- 6-99 | 3.81 | 4 | 461 |
| St. Paul, Minn... | 6-28-01 | 3.80 | 2 | 463 |
| St. Paul, Minn... | 9- 5-04 | 3.80 | 2 | 465 |
| New Orleans, La.. | 4-17-00 | 3.80 | 1 | 466 |
| Dodge City, Kans. | 7-23-99 | 3.78 | 3 | 469 |
| St. Louis, Mo.... | 7- 4-99 | 3.78 | 4 | 473 |
| Lexington, Ky.... | 8-23-05 | 3.78 | 1 | 474 |
| New Orleans, La.. | 7-11-07 | 3.77 | 1 | 475 |
| Wichita, Kans.... | 6- 2-04 | 3.76 | 10 | 485 |
| Kansas City, Mo.. | 9- 5-98 | 3.76 | 7 | 492 |
| Davenport, Ia..... | 9- 1-05 | 3.75 | 7 | 499 |
| Oklahoma City Okla. ......... | 8-28-00 | 3.75 | 4 | 503 |
| Davenport, Ia..... | 9-14-03 | 3.74 | 7 | 510 |
| Lexington, Ky.... | 8-22-00 | 3.72 | 1 | 511 |
| Columbia, Mo..... | 10-16-05 | 3.72 | 5 | 516 |
| New Orleans, La.. | 7-11-04 | 3.70 | 1 | 517 |
| Columbia, Mo.... | 7-31-99 | 3.69 | 5 | 522 |
| Ft. Worth, Tex.. | 5-11-05 | 3.68 | 3 | 523 |
| Kansas City, Mo.. | 8- 2-05 | 3.67 | 7 | 530 |
| Hannibal, Mo..... | 9-25-98 | 3.67 | 5 | 535 |
| Wichita, Kans..... | 7-14-04 | 3.66 | 10 | 545 |
| Kansas City, Mo.. | 9-14-05 | 3.66 | 7 | 552 |
| Yankton, S. D.... | 7- 8-98 | 3.66 | 3 | 555 |
| New Orleans, La.. | 3-14-03 | 3.66 | 1 | 556 |
| Wichita, Kans..... | 6-15-05 | 3.64 | 10 | 566 |
| New Orleans, La.. | 8-12-06 | 3.63 | 1 | 567 |
| New Orleans, La.. | 8-22-03 | 3.62 | 1 | 568 |
| Valentine, Neb... | 7-21-04 | 3.62 | 3 | 571 |
| St. Paul, Minn... | 6-14-01 | 3.62 | 2 | 573 |
| Yankton, S. D.... | 5-24-06 | 3.62 | 3 | 576 |
| Topeka, Kans..... | 8-26-02 | 3.61 | 7 | 583 |
| Lincoln, Neb..... | 4-23-97 | 3.60 | 6 | 589 |

| City. | Date. | Av. Rate per hr. | Final Wt. | Partial Tls. |
|---|---|---|---|---|
| Indianapolis, Ind.. | 7- 6-04 | 3.60 | 2 | 591 |
| Oklahoma City Okla. .......... | 5-29-05 | 3.60 | 4 | 595 |
| Denver, Colo..... | 9-20-02 | 3.60 | 1 | 596 |
| Ft. Smith, Ark... | 8-26-04 | 3.58 | 7 | 603 |
| Des Moines, Ia... | 7-16-07 | 3.57 | 5 | 608 |
| Dodge City, Kans. | 7-21-07 | 3.56 | 3 | 611 |
| Shreveport, La.... | 6-27-02 | 3.56 | 4 | 615 |
| La Crosse, Wis... | 7-21-07 | 3.56 | 5 | 620 |
| Little Rock, Ark.. | 11-28-05 | 3.56 | 3 | 623 |
| Columbia, Mo..... | 9-18-04 | 3.54 | 5 | 628 |
| Evansville, Ind... | 9- 2-00 | 3.54 | 4 | 632 |
| New Orleans, La.. | 6-27-04 | 3.54 | 1 | 633 |
| Milwaukee, Wis... | 9- 2-00 | 3.54 | 2 | 635 |
| New Orleans, La.. | 3-14-03 | 3.54 | 1 | 636 |
| Indianapolis, Ind.. | 3-31-04 | 3.53 | 2 | 638 |
| Shreveport, La.... | 4- 2-05 | 3.53 | 4 | 642 |
| St. Paul, Minn... | 8- 4-05 | 3.52 | 2 | 644 |
| Omaha, Neb...... | 7-18-07 | 3.52 | 5 | 649 |
| Wichita, Kans.... | 6- 2-05 | 3.52 | 10 | 659 |
| Wichita, Kans.... | 8-16-07 | 3.50 | 10 | 669 |
| Wichita, Kans.... | 5-20-03 | 3.50 | 10 | 679 |
| Kansas City, Mo.. | 8-21-04 | 3.50 | 7 | 686 |
| Oklahoma City Okla. .......... | 5- 5-99 | 3.50 | 4 | 690 |
| Bismarck, N. D.. | 6- 4-05 | 3.50 | 1 | 691 |
| Dubuque, Ia...... | 8-15-07 | 3.50 | 5 | 696 |
| Indianapolis, Ind.. | 8-19-06 | 3.49 | 2 | 698 |
| Kansas City, Mo.. | 5-24-05 | 3.48 | 7 | 705 |
| Cincinnati, O..... | 7- 5-97 | 3.46 | 1 | 706 |
| Columbus, O....... | 7-28-02 | 3.46 | 1 | 707 |
| Oklahoma City Okla. ......... | 9-11-06 | 3.46 | 4 | 711 |
| Nashville, Tenn... | 9- 4-06 | 3.45 | 2 | 713 |
| Hannibal, Mo..... | 7- 7-98 | 3.44 | 5 | 718 |
| Indianapolis, Ind.. | 8- 2-99 | 3.44 | 2 | 720 |
| Nashville, Tenn... | 9- 1-00 | 3.44 | 2 | 722 |
| Evansville, Ind... | 6- 2-04 | 3.44 | 4 | 726 |
| Huron, S. D..... | 8- 8-01 | 3.44 | 2 | 728 |
| Dodge City, Kans. | 8-16-07 | 3.44 | 3 | 731 |
| Yankton, S. D... | 7-14-00 | 3.43 | 3 | 734 |
| Lincoln, Neb...... | 8- 4-02 | 3.42 | 6 | 740 |
| Omaha, Neb...... | 6-26-06 | 3.42 | 5 | 745 |

(745 weighted rains every 2 years.)

| City. | Date. | Av. Rate per hr. | Final Wt. | Partial Tls. |
|---|---|---|---|---|
| Springfield, Mo... | 8-14-05 | 3.42 | 10 | 755 |
| St. Paul, Minn... | 9-25-06 | 3.42 | 2 | 757 |
| New Orleans, La.. | 8-24-03 | 3.42 | 1 | 758 |
| Chicago, Ill....... | 5-11-05 | 3.42 | 2 | 760 |
| Huron, S. D..... | 6-27-05 | 3.41 | 2 | 762 |
| Ft. Worth, Tex... | 5- 3-04 | 3.40 | 3 | 765 |
| Milwaukee, Wis... | 8-23-98 | 3.39 | 2 | 767 |
| Ft. Smith, Ark... | 6-30-07 | 3.39 | 7 | 774 |
| Springfield, Mo... | 7-19-06 | 3.38 | 10 | 784 |
| Memphis, Tenn... | 8- 9-05 | 3.38 | 3 | 787 |
| St. Louis, Mo.... | 5-31-03 | 3.37 | 4 | 791 |
| Kansas City, Mo.. | 3-24-04 | 3.36 | 7 | 798 |
| New Orleans, La.. | 8-22-03 | 3.35 | 1 | 799 |
| Lexington, Ky.... | 5-10-05 | 3.35 | 1 | 800 |
| Memphis, Tenn.... | 11-19-06 | 3.34 | 3 | 803 |
| Yankton, S. D... | 8-23-06 | 3.34 | 3 | 806 |
| Evansville, Ind... | 7-20-04 | 3.34 | 4 | 810 |
| Shreveport, La.... | 5-21-05 | 3.33 | 4 | 814 |
| New Orleans, La.. | 9-16-01 | 3.33 | 1 | 815 |
| Bismarck, N. D.. | 10- 1-98 | 3.33 | 1 | 816 |
| Huron, S. D..... | 6-24-02 | 3.33 | 2 | 818 |
| Louisville, Ky.... | 7-10-97 | 3.32 | 2 | 820 |
| Des Moines, Ia.. | 4-22-97 | 3.32 | 5 | 825 |
| Shreveport, La.... | 5- 7-07 | 3.31 | 4 | 829 |
| Cincinnati, O...... | 8- 3-00 | 3.30 | 1 | 830 |
| Dodge City, Kan. | 7-19-97 | 3.30 | 3 | 833 |
| Huron, S. D..... | 6-12-00 | 3.30 | 2 | 835 |

| City. | Date. | Av. Rate per hr. | Final Wt. | Partial Tls. |
|---|---|---|---|---|
| Oklahoma City Okla. .......... | 8- 7-06 | 3.28 | 4 | 839 |
| Shreveport, La.... | 5- 3-06 | 3.28 | 4 | 843 |
| Chicago, Ill....... | 7- 1-01 | 3.28 | 2 | 845 |
| Shreveport, La.... | 7-23-02 | 3.27 | 4 | 852 |
| Valentine, Neb... | 7-11-06 | 3.26 | 3 | 848 |
| Kansas City, Mo.. | 5-23-02 | 3.26 | 7 | 859 |
| Nashville, Tenn... | 7-11-97 | 3.25 | 2 | 861 |
| Topeka, Kans..... | 7-28-01 | 3.24 | 7 | 868 |
| Little Rock, Ark.. | 8-25-99 | 3.24 | 3 | 871 |
| Evansville, Ind... | 8-14-06 | 3.22 | 4 | 875 |
| Little Rock, Ark.. | 7-29-00 | 3.22 | 3 | 878 |
| St. Paul, Minn... | 10- 3-03 | 3.22 | 2 | 880 |
| New Orleans, La.. | 6- 4-05 | 3.22 | 1 | 881 |
| St. Louis, Mo.... | 5- 5-00 | 3.21 | 4 | 885 |
| Yankton, S. D... | 7-10-07 | 3.20 | 3 | 888 |
| Kansas City, Mo.. | 7-19-06 | 3.20 | 7 | 895 |
| Kansas City, Mo.. | 9- 6-05 | 3.20 | 7 | 902 |
| Nashville, Tenn... | 6-27-04 | 3.18 | 2 | 904 |
| Little Rock, Ark.. | 4-24-05 | 3.18 | 3 | 907 |
| Springfield, Mo... | 6- 4-04 | 3.18 | 10 | 917 |
| Columbia, Mo..... | 10-28-00 | 3.18 | 5 | 922 |
| Columbus, O..... | 7-19-00 | 3.17 | 1 | 923 |
| Lexington, Ky.... | 7-19-02 | 3.16 | 1 | 924 |
| St. Louis, Mo.... | 5-21-98 | 3.15 | 4 | 928 |
| Valentine, Neb... | 7- 9-07 | 3.14 | 3 | 931 |
| Little Rock, Ark.. | 6-22-04 | 3.14 | 3 | 934 |

| City. | Date. | Av. Rate per hr. | Final Wt. | Partial Tls. |
|---|---|---|---|---|
| Nashville, Tenn... | 6- 9-03 | 3.13 | 2 | 936 |
| New Orleans, La.. | 6- 7-04 | 3.12 | 1 | 937 |
| Memphis, Tenn... | 7-16-06 | 3.12 | 3 | 940 |
| Oklahoma City Okla. .......... | 5-28-03 | 3.12 | 4 | 944 |
| Columbia, Mo..... | 5-25-03 | 3.12 | 5 | 949 |
| Kansas City, Mo... | 6-22-01 | 3.12 | 7 | 956 |
| Des Moines, Ia... | 4-17-00 | 3.12 | 5 | 961 |
| Columbus, O...... | 7-20-97 | 3.10 | 1 | 962 |
| Oklahoma City Okla. .......... | 3-25-02 | 3.10 | 4 | 966 |
| Springfield, Mo... | 6-24-06 | 3.10 | 10 | 976 |
| Lincoln, Neb..... | 8- 4-07 | 3.10 | 6 | 982 |
| Columbia, Mo..... | 4-25-02 | 3.09 | 5 | 987 |
| Huron, S. D..... | 6-17-04 | 3.08 | 2 | 989 |
| New Orleans, La.. | 11-22-01 | 3.08 | 1 | 990 |
| Dodge City, Kans. | 10- 9-98 | 3.08 | 3 | 993 |
| New Orleans, La.. | 7-11-06 | 3.07 | 1 | 994 |
| Valentine, Neb... | 7- 6-07 | 3.06 | 3 | 997 |
| Wichita, Kans..... | 10-30-03 | 3.04 | 10 | 1007 |
| New Orleans, La.. | 11- 9-98 | 3.02 | 1 | 1008 |
| Columbia, Mo..... | 4-24-04 | 3.02 | 5 | 1013 |
| New Orleans, La.. | 8- 3-02 | 3.01 | 1 | 1014 |
| Lincoln, Neb..... | 5-28-05 | 3.00 | 6 | 1020 |
| Kansas City, Mo.. | 8-15-03 | 3.00 | 7 | 1027 |
| Oklahoma City Okla. .......... | 5-23-03 | 3.00 | 4 | 1031 |
| Springfield, Ill... | 5- 5-01 | 3.00 | 6 | 1037 |
| Denver, Colo..... | 6- 2-00 | 3.00 | 1 | 1038 |
| Evansville, Ind... | 9- 2-04 | 3.00 | 4 | 1042 |
| Ft. Worth, Tex... | 6-24-03 | 3.00 | 3 | 1045 |
| Memphis, Tenn... | 6-23-99 | 2.99 | 3 | 1048 |
| Evansville, Ind... | 7-10-05 | 2.98 | 4 | 1052 |
| Yankton, S. D.... | 9-20-02 | 2.98 | 3 | 1055 |
| Hannibal, Mo..... | 7- 4-99 | 2.98 | 5 | 1060 |
| Des Moines, Ia... | 7-18-04 | 2.97 | 5 | 1065 |
| Topeka, Kans..... | 7-31-02 | 2.87 | 7 | 1072 |
| Ft. Worth, Tex... | 9-21-00 | 2.96 | 3 | 1075 |
| Kansas City, Mo.. | 7-14-07 | 2.96 | 7 | 1082 |
| New Orleans, La.. | 8- 3-98 | 2.95 | 1 | 1083 |
| Hannibal, Mo..... | 8- 8-99 | 2.93 | 5 | 1088 |
| Omaha, Neb...... | 7-15-00 | 2.92 | 5 | 1093 |
| Kansas City, Mo.. | 9- 9-03 | 2.92 | 7 | 1100 |
| Memphis, Tenn... | 8-30-97 | 2.92 | 3 | 1103 |
| Cairo, Ill......... | 6- 7-00 | 2.92 | 3 | 1106 |
| Bismarck, N. D.. | 6-16-97 | 2.92 | 1 | 1107 |
| New Orleans, La.. | 7-25-99 | 2.92 | 1 | 1108 |
| New Orleans, La.. | 7- 7-98 | 2.90 | 1 | 1109 |
| New Orleans, La.. | 8- 5-98 | 2.90 | 1 | 1110 |
| Indianapolis, Ind.. | 5-29-00 | 2.90 | 2 | 1112 |
| Louisville, Ky..... | 3-16-98 | 2.90 | 2 | 1114 |
| Chicago, Ill....... | 7- 9-03 | 2.90 | 2 | 1116 |
| Evansville, Ind... | 5-30-00 | 2.90 | 4 | 1120 |
| St. Paul, Minn... | 10- 3-00 | 2.90 | 2 | 1122 |
| Memphis, Tenn... | 8-18-01 | 2.88 | 3 | 1125 |
| Chicago, Ill....... | 5-24-02 | 2.87 | 2 | 1127 |
| New Orleans, La.. | 7-18-00 | 2.86 | 1 | 1128 |
| Hannibal, Mo..... | 8- 8-99 | 2.86 | 1 | 1129 |
| Cincinnati, O..... | 7-21-03 | 2.85 | 1 | 1130 |
| Kansas City, Mo.. | 7- 2-05 | 2.84 | 7 | 1137 |
| Louisville, Ky.... | 6-15-02 | 2.83 | 2 | 1139 |
| Ft. Worth, Tex... | 10-21-00 | 2.82 | 3 | 1142 |
| Springfield, Ill... | 6- 1-02 | 2.82 | 6 | 1148 |
| New Orleans, La.. | 7-17-97 | 2.81 | 1 | 1149 |
| Lincoln, Neb...... | 7-22-02 | 2.80 | 6 | 1155 |
| Lincoln, Neb...... | 5-10-05 | 2.80 | 6 | 1161 |
| Little Rock, Ark.. | 6- 1-98 | 2.80 | 3 | 1164 |

| City. | Date. | Av. Rate per hr. | Final Wt. | Partial Tls. |
|---|---|---|---|---|
| New Orleans, La.. | 10- 7-00 | 2.80 | 1 | 1165 |
| New Orleans, La.. | 5-23-07 | 2.80 | 1 | 1166 |
| Columbia, Mo..... | 10- 6-00 | 2.78 | 5 | 1171 |
| St. Louis, Mo.... | 7-29-03 | 2.78 | 4 | 1175 |
| St. Paul, Minn... | 7-30-04 | 2.78 | 2 | 1177 |
| Milwaukee, Wis... | 7-21-07 | 2.76 | 2 | 1179 |
| Ft. Worth, Tex... | 5-24-07 | 2.74 | 3 | 1182 |
| Yankton, S. D... | 9-20-02 | 2.73 | 3 | 1185 |
| Hannibal, Mo..... | 6- 4-04 | 2.73 | 5 | 1190 |
| Milwaukee, Wis... | 9-14-03 | 2.72 | 2 | 1192 |
| Dodge City, Kans. | 7-28-00 | 2.72 | 3 | 1195 |
| New Orleans, La.. | 7- 4-03 | 2.72 | 1 | 1196 |
| Dubuque, Ia...... | 9-25-04 | 2.72 | 5 | 1201 |
| Davenport, Ia..... | 9- 9-03 | 2.70 | 7 | 1208 |
| La Crosse, Wis... | 8- 4-05 | 2.70 | 5 | 1213 |
| St. Paul, Minn... | 8-18-07 | 2.70 | 2 | 1215 |
| St. Paul, Minn... | 7-25-97 | 2.70 | 2 | 1217 |
| Little Rock, Ark.. | 7-29-03 | 2.68 | 3 | 1220 |
| Valentine, Neb.... | 6-27-05 | 2.68 | 3 | 1223 |
| Oklahoma City Okla. .......... | 5-21-03 | 2.68 | 4 | 1227 |
| Dodge City, Kans. | 8- 6-03 | 2.66 | 3 | 1238 |
| Memphis, Tenn... | 5-26-02 | 2.64 | 3 | 1230 |
| Omaha, Neb...... | 8-26-03 | 2.63 | 5 | 1235 |
| Huron, S. D..... | 8-18-04 | 2.63 | 2 | 1240 |
| New Orleans, La.. | 3-19-05 | 2.63 | 1 | 1241 |
| Nashville, Tenn... | 9-14-01 | 2.61 | 2 | 1243 |
| Lincoln, Neb...... | 9-14-06 | 2.61 | 6 | 1249 |
| Lincoln, Neb...... | 8- 7-07 | 2.60 | 6 | 1255 |
| Omaha, Neb...... | 6-16-00 | 2.60 | 5 | 1260 |
| Springfield, Mo... | 8- 7-06 | 2.60 | 10 | 1270 |
| Cairo, Ill......... | 7-30-01 | 2.60 | 3 | 1273 |
| Cairo, Ill......... | 6-22-97 | 2.58 | 3 | 1276 |
| Evansville, Ind... | 5-31-07 | 2.58 | 4 | 1280 |
| Des Moines, Ia... | 5-21-03 | 2.56 | 5 | 1285 |
| Milwaukee, Wis... | 6-12-99 | 2.55 | 2 | 1287 |
| St. Paul, Minn... | 6-12-99 | 2.54 | 2 | 1289 |
| Indianapolis, Ind.. | 6- 4-06 | 2.54 | 2 | 1291 |
| Oklahoma City Okla. .......... | 8-11-02 | 2.52 | 4 | 1295 |
| Topeka, Kans..... | 8- 4-06 | 2.52 | 7 | 1302 |
| Huron, S. D..... | 8- 4-00 | 2.51 | 2 | 1304 |
| Springfield, Ill.... | 8- 3-05 | 2.50 | 6 | 1310 |
| Columbia, Mo..... | 7-18-02 | 2.50 | 5 | 1315 |
| Dodge City, Kan. | 5-13-98 | 2.46 | 3 | 1318 |
| Little Rock, Ark.. | 9-10-99 | 2.44 | 3 | 1321 |
| Memphis, Tenn... | 3-26-02 | 2.44 | 3 | 1324 |
| New Orleans, La.. | 9- 9-98 | 2.43 | 1 | 1325 |
| Huron, S. D...... | 5- 9-05 | 2.41 | 2 | 1327 |
| Ft. Worth, Tex... | 8-11-06 | 2.40 | 3 | 1330 |
| Oklahoma City Okla. .......... | 8-12-01 | 2.38 | 4 | 1334 |
| Ft. Smith, Ark... | 9- 2-06 | 2.38 | 7 | 1341 |
| Columbus, O..... | 8-15-00 | 2.31 | 1 | 1342 |
| New Orleans, La.. | 7- 5-02 | 2.30 | 1 | 1343 |
| Kansas City, Mo.. | 7- 5-04 | 2.22 | 7 | 1350 |
| Oklahoma City Okla. .......... | 7-20-97 | 2.16 | 4 | 1354 |
| Little Rock, Ark.. | 12-13-01 | 2.10 | 3 | 1357 |
| Kansas City, Mo.. | 7- 7-02 | 1.94 | 7 | 1364 |
| Des Moines, Ia... | 7-23-00 | 1.90 | 5 | 1369 |
| New Orleans, La.. | 4-25-07 | 1.90 | 1 | 1370 |
| Lincoln, Neb...... | 5-24-03 | 1.81 | 6 | 1376 |
| Lincoln, Neb...... | 9-16-06 | 1.79 | 6 | 1382 |
| Hannibal, Mo..... | 8-10-99 | 1.73 | 5 | 1387 |
| Columbia, Mo..... | 6- 7-98 | 1.66 | 5 | 1392 |

Table VI.

| Cities. | Years considered. | Years of record. | Dist. wght. | Final wght. |
|---|---|---|---|---|
| Kansas City, Mo.. | 10 | 10 | 7 | 7 |
| Topeka, Kans..... | 10 | 8½ | 6 | 7 |
| Wichita, Kans.... | 10 | 5 | 5 | 10 |
| Lincoln, Neb...... | 10 | 11 | 5 | 6 |
| Omaha, Neb...... | 10 | 11 | 5 | 5 |
| Des Moines, Ia... | 10 | 11 | 5 | 6 |
| Hannibal, Mo..... | 10 | 9½ | 5 | 5 |
| Columbia, Mo..... | 10 | 10 | 5 | 5 |
| Springfield, Mo... | 10 | 5 | 5 | 10 |
| Oklahoma City Okla. .......... | 10 | 10½ | 4 | 4 |
| Davenport, Ia..... | 10 | 6 | 4 | 7 |

| Cities. | Years considered. | Years of record. | Dist. wght. | Final wght. |
|---|---|---|---|---|
| Springfield, Ill.... | 10 | 6½ | 4 | 6 |
| St. Louis, Mo.... | 10 | 11 | 4 | 4 |
| Ft. Smith, Ark.. | 10 | 6 | 4 | 7 |
| Dodge City, Kans. | 10 | 11 | 3 | 3 |
| Yankton, S. D... | 10 | 10½ | 3 | 3 |
| La Crosse, Wis... | 10 | 6 | 3 | 5 |
| Dubuque, Ia...... | 10 | 5½ | 3 | 5 |
| Evansville, Ind... | 10 | 8 | 3 | 4 |
| Cairo, Ill......... | 10 | 10½ | 3 | 3 |
| Memphis, Tenn... | 10 | 11 | 3 | 3 |
| Little Rock, Ark.. | 10 | 11 | 3 | 3 |
| Ft. Worth, Tex... | 10 | 7½ | 2 | 3 |
| Valentine, Neb.... | 10 | 6 | 2 | 3 |
| Huron, S. D..... | 10 | 10 | 2 | 2 |
| St. Paul, Minn.. | 10 | 11 | 2 | 2 |
| Milwaukee, Wis... | 10 | 11 | 2 | 2 |

| Cities. | Years considered. | Years of record. | Dist. wght. | Final wght. |
|---|---|---|---|---|
| Chicago, Ill....... | 10 | 11 | 2 | 2 |
| Indianapolis, Ind.. | 10 | 11 | 2 | 2 |
| Louisville, Ky.... | 10 | 11 | 2 | 2 |
| Nashville, Tenn.... | 10 | 11 | 2 | 2 |
| Shreveport, La.... | 10 | 5½ | 2 | 4 |
| Pueblo, Colo...... | 10 | 8 | 1 | 1 |
| Denver, Colo..... | 10 | 11 | 1 | 1 |
| Bismarck, N. D.. | 10 | 11 | 1 | 1 |
| Columbus, O...... | 10 | 10½ | 1 | 1 |
| Cincinnati, O..... | 10 | 11 | 1 | 1 |
| Lexington, Ky.... | 10 | 9 | 1 | 1 |
| New Orleans, La.. | 10 | 11 | 1 | 1 |

Total final weight................149
Twice the final weight............298
Five times the final weight.......745

Table VII. Precipitations Used in Determining Form of 40 Min. Typical Rain Curve, Giving Depth in Inches for Each 5 Minutes.

Five Minute Intervals.

From Beginning of the Downpour.

| Cities— | Date | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Evansville, Ind. | 9- 2-00 | .08 | .09 | .09 | .17 | .26 | .32 | .28 | .21 | .15 | .21 | .20 | .14 | | | |
| Lexington, Ky. | 8-22-00 | .22 | .21 | .25 | 28 | .36 | .21 | .13 | .15 | .05 | .10 | .04 | .01 | | | |
| Columbia, Mo. | 8-22-05 | .04 | .08 | .06 | .20 | .34 | .42 | .36 | .24 | .12 | .06 | .03 | .07 | | | |
| Shreveport, La. | 6- 1-06 | .08 | .20 | .31 | .39 | .17 | .22 | .20 | .16 | .11 | .10 | .05 | .01 | | | |
| New Orleans, La. | 3-14-03 | .07 | .32 | .35 | .25 | .17 | .13 | .10 | .29 | .07 | .24 | .22 | .32 | .29 | .16 | .08 |
| Springfield, Mo. | 7-26-05 | .07 | .14 | .20 | .32 | .43 | .26 | .34 | .17 | .06 | .08 | .12 | .22 | .12 | .10 | .04 |

Table VIII. The Same as the Above, Except that the Arrangement is Symmetrical, as Shown in Fig. 5.

Five Minute Intervals.

| Cities— | No. | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Evansville | 1 | | | .08 | .09 | .09 | 17 | .26 | .32 | .28 | .21 | .15 | .21 | .20 | .14 | | | | |
| Lexington | 2 | | | | .22 | .21 | .25 | .28 | .36 | .21 | .13 | .15 | .05 | .10 | .04 | .01 | | | |
| Columbia | 3 | | | .04 | .08 | .06 | .20 | .34 | .42 | .36 | .24 | .12 | .06 | .03 | .07 | | | | |
| Shreveport | 4 | | | | | .08 | .20 | .31 | .39 | .17 | .22 | .20 | .16 | .11 | .10 | .05 | .01 | | |
| New Orleans | 5 | .07 | .32 | .35 | .25 | .17 | .13 | .10 | .29 | .07 | .24 | .22 | .32 | .29 | .16 | .08 | | | |
| Springfield | 6 | | | | .07 | .14 | .20 | .32 | .43 | .26 | .34 | .17 | .06 | .08 | .12 | .22 | .12 | .10 | .04 |

Table IX. Showing Method of Obtaining Typical Intensities. The Data is that of Table VII Multiplied by the Weights Given.

Weighted Five Minute Intervals.

| No. | Weight. | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 4 | | | .32 | .36 | .36 | .68 | 1.04 | 1.28 | 1.12 | .84 | .60 | .84 | .80 | .56 | | | | |
| 2 | 1 | | | | .22 | .21 | .25 | .28 | .36 | .21 | .13 | .15 | .05 | .10 | .04 | .01 | | | |
| 3 | 5 | | | .20 | .40 | .30 | 1.00 | 1.70 | 2.10 | 1.80 | 1.20 | .75 | .25 | .15 | .35 | .05 | | | |
| 4 | 4 | | | | | .32 | .80 | 1.24 | 1.56 | .68 | .88 | .80 | .64 | .44 | .40 | .20 | .04 | | |
| 5 | 1 | .07 | .32 | .35 | .25 | .17 | .13 | .10 | .29 | .07 | .24 | .22 | .32 | .29 | .16 | .08 | | | |
| 6 | 5 | | | | .35 | .70 | 1.00 | 1.60 | 2.15 | 1.30 | 1.70 | .85 | .30 | .40 | .60 | 1.10 | .60 | .50 | .20 |
| Total | 20 | .07 | .32 | .87 | 1.58 | 2.06 | 3.86 | 5.96 | 7.74 | 5.18 | 4.99 | 3.37 | 2.40 | 2.18 | 2.11 | 1.44 | .64 | .50 | .20 |
| Average | | .00 | .01 | .04 | .08 | .10 | .19 | .30 | .39 | .26 | .25 | .17 | .12 | .11 | .11 | .07 | .03 | .03 | .01 |
| Hourly rate | | .00 | .12 | .48 | .96 | 1.20 | 2.28 | 3.60 | 4.68 | 3.12 | 3.00 | 2.04 | 1.44 | 1.32 | 1.32 | .84 | .36 | .36 | .12 |